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Final Report

June 1969

5A-11101-4334A-06

VULNERABILITY OF THE ALBUQUERQUE WATER SUPPLY SYSTEM

Prepared for:

OFFICE OF CIVIL DEFENSE
OFFICE OF THE SECRETARY OF THE ARMY
WASHINGTON, D.C. 20310

CONTRACT DAHC-20-67-C-0136
OCD Work Unit 4334A

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Final Report
Detachable Summary

June 1969
5A 11101-4334A 06

VULNERABILITY OF THE ALBUQUERQUE WATER SUPPLY SYSTEM

By: ROBERT L. NEVIN

Prepared for:

OFFICE OF CIVIL DEFENSE
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OCD REVIEW NOTICE

SUMMARY

As a part of the Five City Study, an analysis has been made of the damage to the Albuquerque New Mexico water system due to a hypothetical five megaton nuclear burst at elevation 14,500 feet near the southeast edge of the city. This burst was assumed to occur at 9:13 p.m., August 24, 1965. No radioactive fallout on Albuquerque would have resulted from this burst, because of the wind direction and velocity, and also because of the height of burst; but fallout would have resulted from four other bursts assumed to have occurred at a considerable distance from the City, starting at about D + 13 hours. This fallout would have decayed so that the radioactivity was less than one roentgen per hour within about a week.

The Albuquerque water system is operated as a municipal utility by a division of the Department of Public Works. The system served about 260,000 people in an area of 75 to 80 square miles in August of 1965.

The water supply came from 68 wells, all electrically operated, and there were 27 booster pumping plants for raising the water to zones of higher elevation. All booster pumps were normally operated electrically, but 8 out of 89 pumps had standby engines operated on natural gas.

Standby water storage, for operating and for fire, was provided by 30 ground storage reservoirs with a total capacity of about 113 million gallons. There was a total of about 900 miles of pipelines in the system, ranging in size from 42 inches in diameter to as small as 3/4 inch in some of the very old parts of the system.

The assumed nuclear blast would have resulted in peak airblast overpressures of 2 pounds per square inch (psi) or more over essentially all of the city. Overpressures would have exceeded 3 psi over 80 percent of the city, 5 psi over 60 percent, and 10 psi over 25 percent. The thermal pulse would have been sufficient to ignite some materials over most of the area. The ground shock would have been sufficient to cause ruptures between surface reservoirs and underground mains over at least 50 percent of the city, and to cause leakage at some services throughout most of the area. An analysis of fire damage by IITRI* indicates that 80 to 90 percent of the buildings in the study area would be burned.

The analysis of water system damage shows that 16 out of the 30 reservoirs would be completely destroyed or so badly damaged as to be useless. The surviving reservoirs would contain about 37 million gallons at the time of the attack, but about 20 million gallons would be lost through leaks in the transmission pipelines at badly damaged reservoirs, and through leakage at services and in building piping. It is assumed that 17 million gallons would be saved by closing all remaining reservoir outlets until the leaks in the distribution system could be isolated.

There would be no power for pumps and no water could be produced from the wells or boosted to delivery pressures for about a week after the attack.

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* "Development and Application of a Computer Fire-Spread Model: Vol. III, Application Phase, Albuquerque," Office of Civil Defense T.O. No. 66-200 (91), Work Unit No. 2538B, IIT Research Insitute, 1968.

The surviving personnel of the Water Division would be adequate for the emergency actions that would be required, but the operations would be hampered by radioactive fallout and by lack of communications in the early postattack period.

There would be adequate water for the critical needs of people in the postattack period, but there would be no water for fire fighting or decontamination. Critical water supplies would have to be hauled to many of the surviving people, until the people could be moved to areas where distribution through pipelines was feasible. It is concluded that after the first few days, recovery of the water system could be achieved at least as fast as the water requirements would increase.

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Final Report

June 1969
5A-11101-4334A-06

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VULNERABILITY OF THE ALBUQUERQUE WATER SUPPLY SYSTEM

By: ROBERT L. NEVIN

Prepared for:

OFFICE OF CIVIL DEFENSE
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WASHINGTON, D.C. 20310

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This report has been reviewed by the Office of Civil Defense and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Civil Defense.

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ABSTRACT

This report assesses the vulnerability of the Albuquerque water supply system to damage from a hypothetical nuclear weapon attack. Probable damage to facilities and casualties to personnel are considered, as well as the possible loss of support from interrelated systems.

Based on the damage and casualty predictions, the postattack capabilities are evaluated, and these capabilities are discussed in relation to post attack requirements. Although the study did not include recovery analysis, some lapse of time and the accomplishment of remedial measures had to be considered to allow a meaningful discussion of capability.

ACKNOWLEDGMENTS

The research covered in this report was conducted in the Facilities and Housing Research Department of Stanford Research Institute under Contract Number OCD-DAHC-20-67-C-0136, Work Unit Number 4334A. Robert L. Nevin served as project leader under the administration of Ellis E. Pickering, and Robert M. Rodden served as Technical Monitor.

Overall technical program guidance for the Office of Civil Defense was provided by Mr. George F. Divine, System Evaluation Division, whose assistance and guidance are sincerely appreciated.

Many useful data, as well as drawings of some water system components, were obtained from Engineering Science Inc., of Arcadia, California, and the assistance of Larry W. Adams of that company is gratefully acknowledged.

Additional detailed information on the facilities, the system operations, and the personnel were obtained from city officials in Albuquerque. Particular thanks are due Frank Bailey, Assistant Chief Water Engineer.

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I INTRODUCTION

This study is an examination of the effects on the Albuquerque, New Mexico, water system due to a hypothetical nuclear attack in August, 1965. The study was authorized by the Office of Civil Defense as a part of Work Unit 4334A, and is one of the many components that make up the Five City Study. An introduction to the concept, conduct and objective of this study must necessarily begin with a description of the Five City Study.

Five City Concept and Process

The concept of the Five City Study is item-by-item examinations of the effects of specified nuclear attacks on five selected localities. The determinations of conditions and effects are made in great detail and provision is made in the design of the study for reiteration of the analyses, based on changed assumptions, such as differing weapon characteristics or the addition of civil defense measures.

Objectives

The objectives of the Five City Study, in addition to the detailed predictions of weapon effects in the five localities, include the development of improved methods for assessment of these effects. The Study is intended to provide an orderly framework and specific nuclear attack situations for general use in the Office of Civil Defense research programs, in order to evaluate the results, prepare studies for operational use, and review the program objectives and requirements.

Organization and Scope

The Five City Study is divided into many component studies or "work units," and these units have been and are being done by many different groups and organizations. However, the Study has been designed to provide for exchanges of information between organizations responsible for the various work units and for sequencing of the work where some components depend on the findings from others.

Water System Study

Figure 1 shows graphically the overall Study design and the information flow between components of the Five City Study. Section 1, the Study Control, and Section 2, the Attack Environment Model, were largely supplied as initial input to this study, although some interpretation was required to relate the specifications and environment model to elements and personnel of the water system. This study is primarily concerned with Section 3, the Target Model, and Section 4, the Damaged Target Model. Information as to weapon effects and general information on property damage and personnel casualties has been obtained from other studies, but this general information has been applied to the specific facilities and personnel of the Albuquerque water system. The objective of this component was to determine the damaged condition of the water system immediately after the attack. (Designated in Figure 1 as CSD/i.)

Engineering-Science, Inc., Arcadia, California, (ESI) has studied some aspects of the water system in preparation of their report on sanitation and waste control for Albuquerque.[1*] Every attempt has been made in the present study to avoid unnecessary duplication of effort and to avoid imposition on the time and patience of Albuquerque City personnel by requests for information that can be obtained from ESI.

Factual material has been borrowed freely and extensively from the ESI report and every item of this material may not be referenced in this report. The conclusions, however, are those of Stanford Research Institute unless specific references indicate otherwise.

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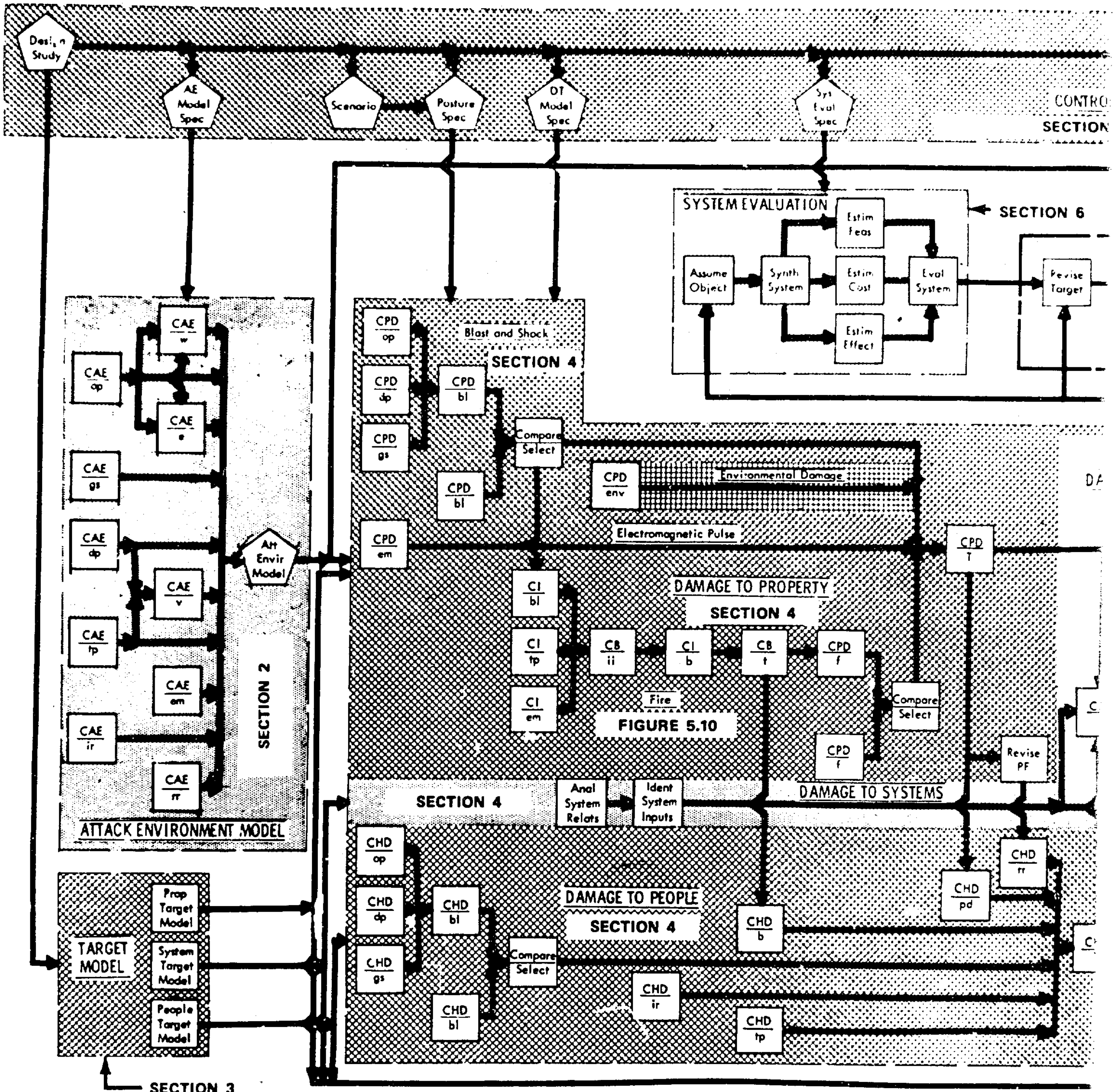
* References are listed at the end of this report.



AFTER "PROCESS DESCRIPTION – FIVE CITY STUDY"
OFFICE OF CIVIL DEFENSE

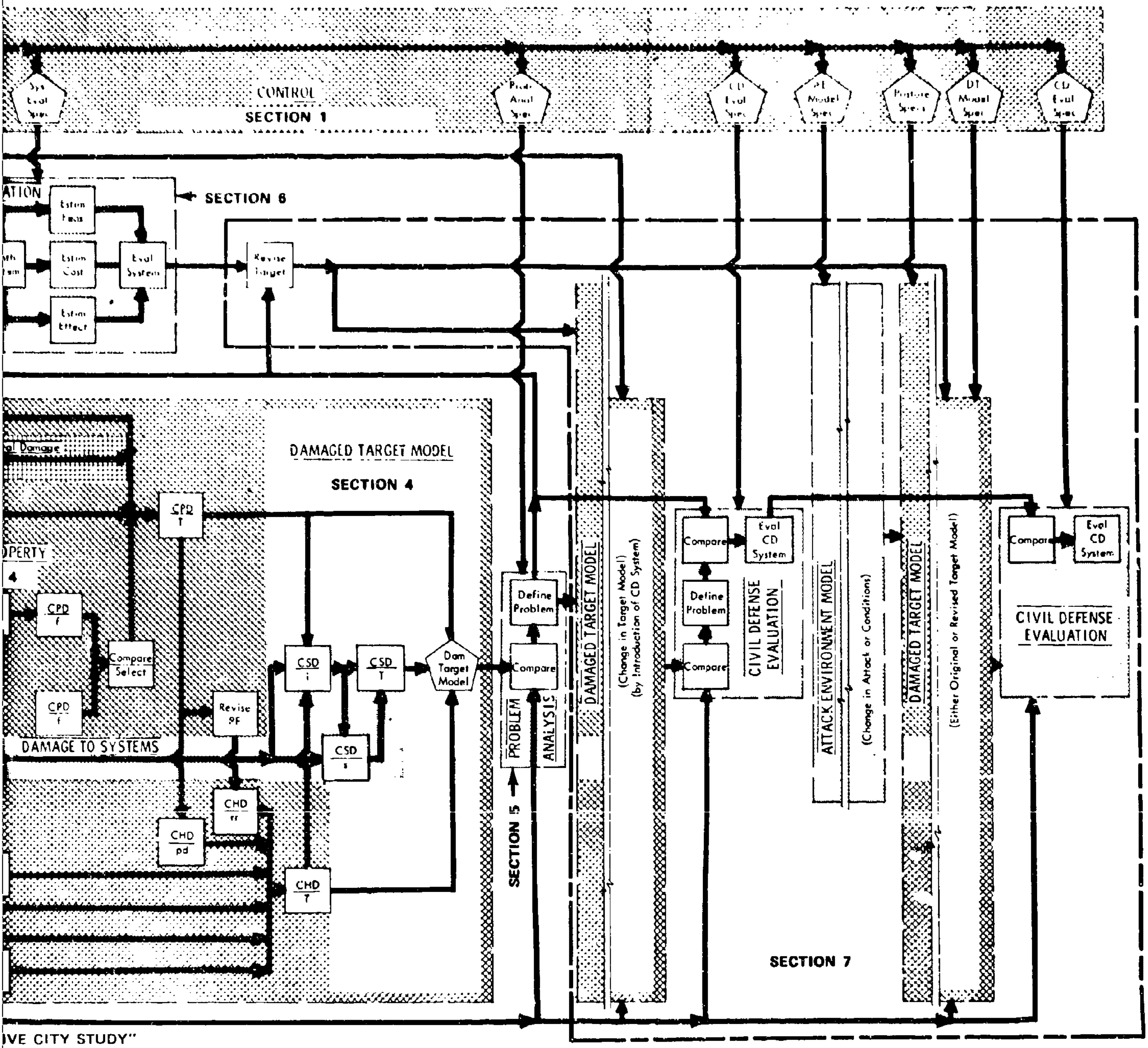


FIGURE 1 FIVE CITY STUDY INFORMATION FLOW DIAGRAM

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II TARGET MODEL

Study Area

The study area includes approximately the corporate city limits of Albuquerque as shown in Figure 2. Information related to matters outside of this area are only considered if they are also relevant to operations or recovery within the city.

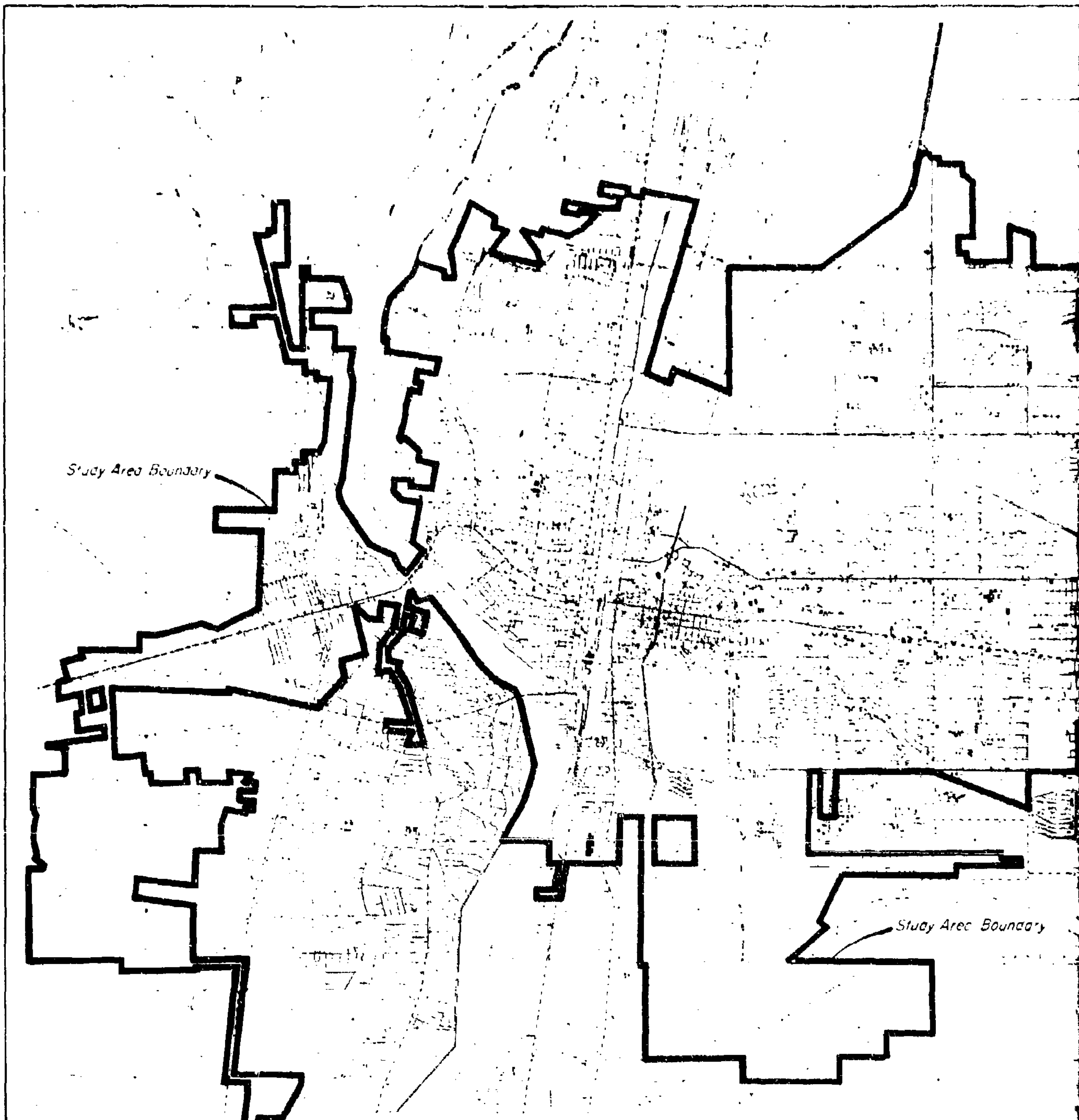
Albuquerque is located in the upper Rio Grande River Basin and is divided in a north-south direction by the River. The elevation of the River within the City limits varies from about 4,990 feet above sea level at the north to about 4,920 feet at the south. The central portion of the City occupies a valley floor delineated by bluffs about three miles apart, plus some area on the mesa above the bluff to the west, and extends to the base of the Sandia and Manzano Mountains to the eastward. The development extends to about 5,100 feet elevation to the west and to about 6,000 feet elevation to the east.

The valley floor consists of unconsolidated alluvial material, with typical variations in material from coarse gravels, cobbles and boulders at some locations and some strata, to silts and clays in others.[2] This alluvial fill in the Rio Grande basin is quite deep, and the so-called "mesas" at the sides of the valley are apparently to a large extent alluvial terraces, and the bluffs were probably formed by down-cutting of the river channel subsequent to the maximum deposition.

Albuquerque has an arid climate, with typically large daily and seasonal temperatures changes, many clear days per year, and low humidity.

The average annual precipitation from 1921 through 1950 was 8.68 inches, with an average of 1.38 inches and 1.05 inches for August and September.[3] A large percentage of the total precipitation occurs during thunderstorms.

There is relatively little industry in Albuquerque but the city is still a major commerce and employment center for this part of New Mexico because of the existence of major highways and railroads, a state university, several large Federal Government installations and numerous State and Federal agency offices. The surrounding area supports a farming and livestock industry.



Study Area Boundary
Study Area Boundary

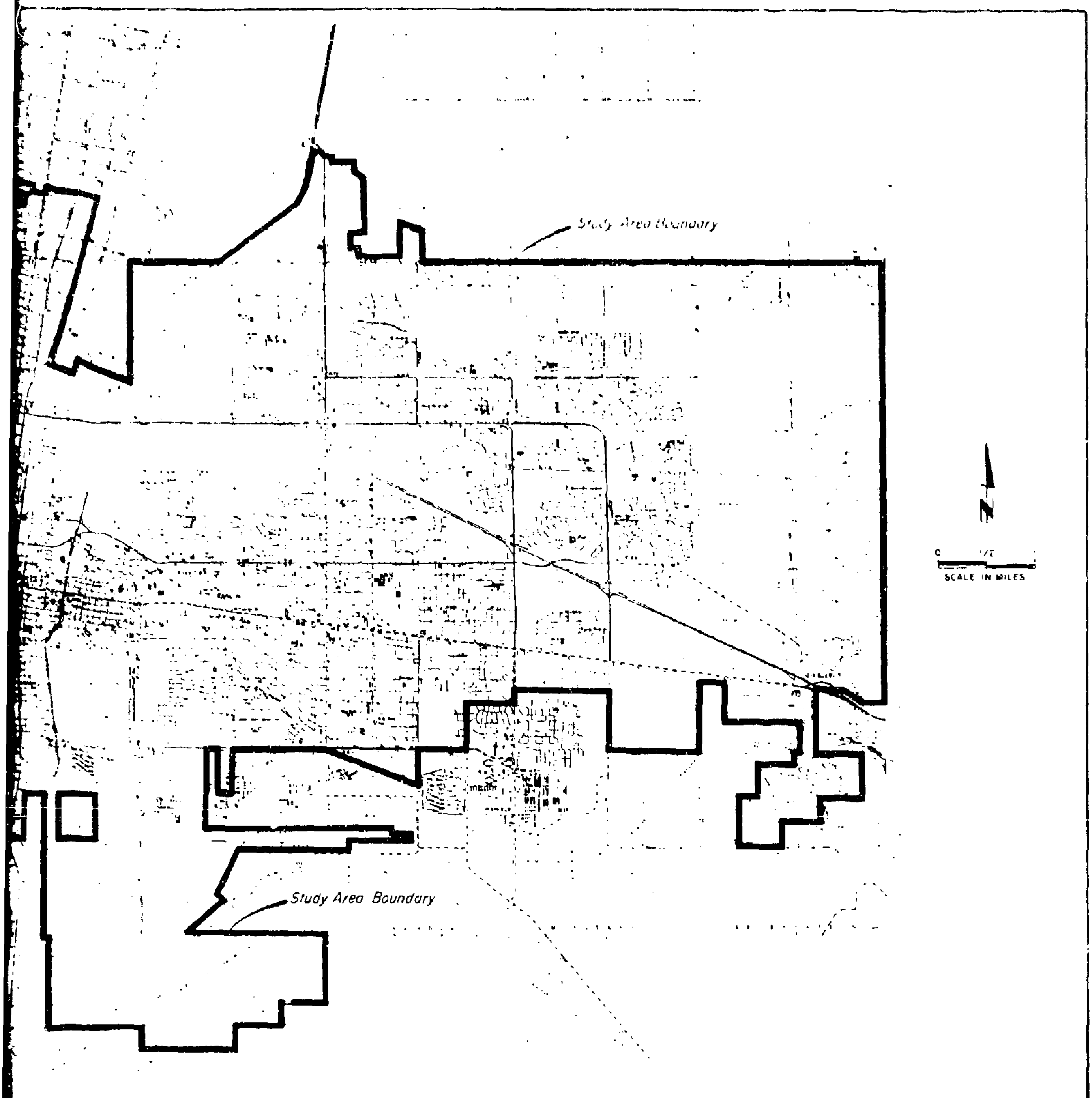


FIGURE 2 STUDY AREA

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Area Population and Housing

The area within the Albuquerque city limits in 1965 was about 75 square miles, lying approximately one-third west of the river and two-thirds east of the river. The population in March of 1965 was estimated at 241,800 by the City Planning Director.

The U.S. Census of population and housing for 1960 shows a population of 204,841 and 61,554 housing units within the study area. Dikewood Corp., in their report on population locations in Albuquerque,[4] gives an estimated population of 261,200 in the same area in August of 1965.

Adjusting the estimate of housing units by the same percentage as the estimated population change indicates a total of 78,710 housing units within the study area in August of 1965.

Property Target Model

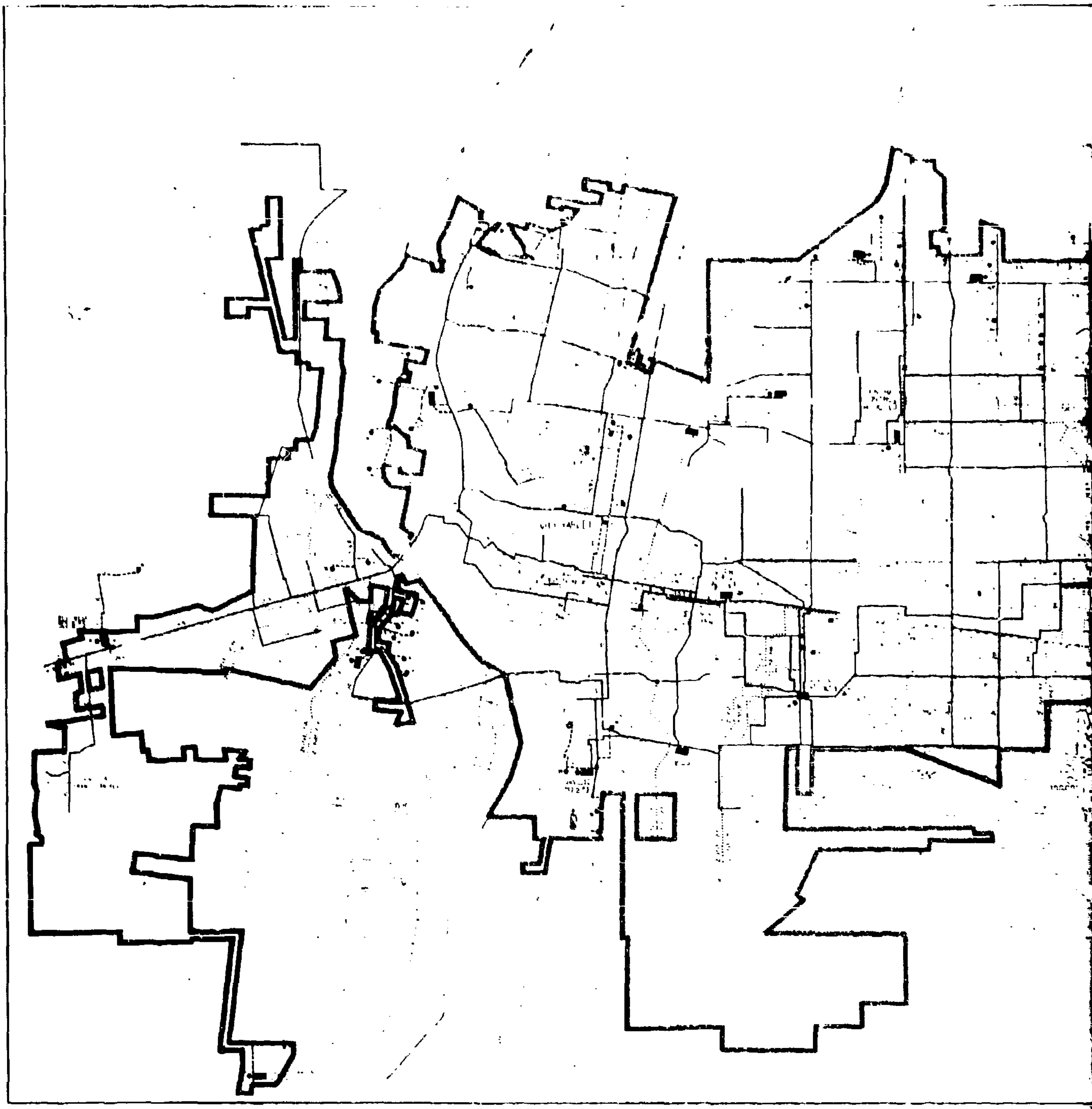
General System Description

The study area is served by the Albuquerque Municipal Water Works, operated as a division of the Public Works Department. This system, shown on Figure 3, supplied about 16,600 million gallons (MG) during 1965, of which 2,038 MG, or about 12.3 percent, was used during August. There were about 62,000 meters on the system at the time. Consumption during the 1965-66 fiscal year varied from a low of 76 gallons per capita per day (gcd) to a high of 353 gcd (on July 3, 1965).

The water supply is entirely from wells with electrically driven pumps. The well pumps in general deliver water into primary reservoirs, from which it is lifted again by booster pumps, but in some cases the primary reservoirs also serve as distribution storage for delivery to the lower pressure zones.

The distribution system is divided into successively higher pressure zones both eastward and westward from the river. As the largest well production is at the lower elevations near the river, much of the delivery depends on successive re-lifting through a series of booster pumping stations. These pumps are also electrically driven, but 4 out of 27 stations have auxiliary gas-fueled engines for two pumps each.

Distribution and fire-standby storage is entirely in ground-storage reservoirs scattered throughout the system. Excess water production is boosted to the higher reservoirs during period of low demand, and can



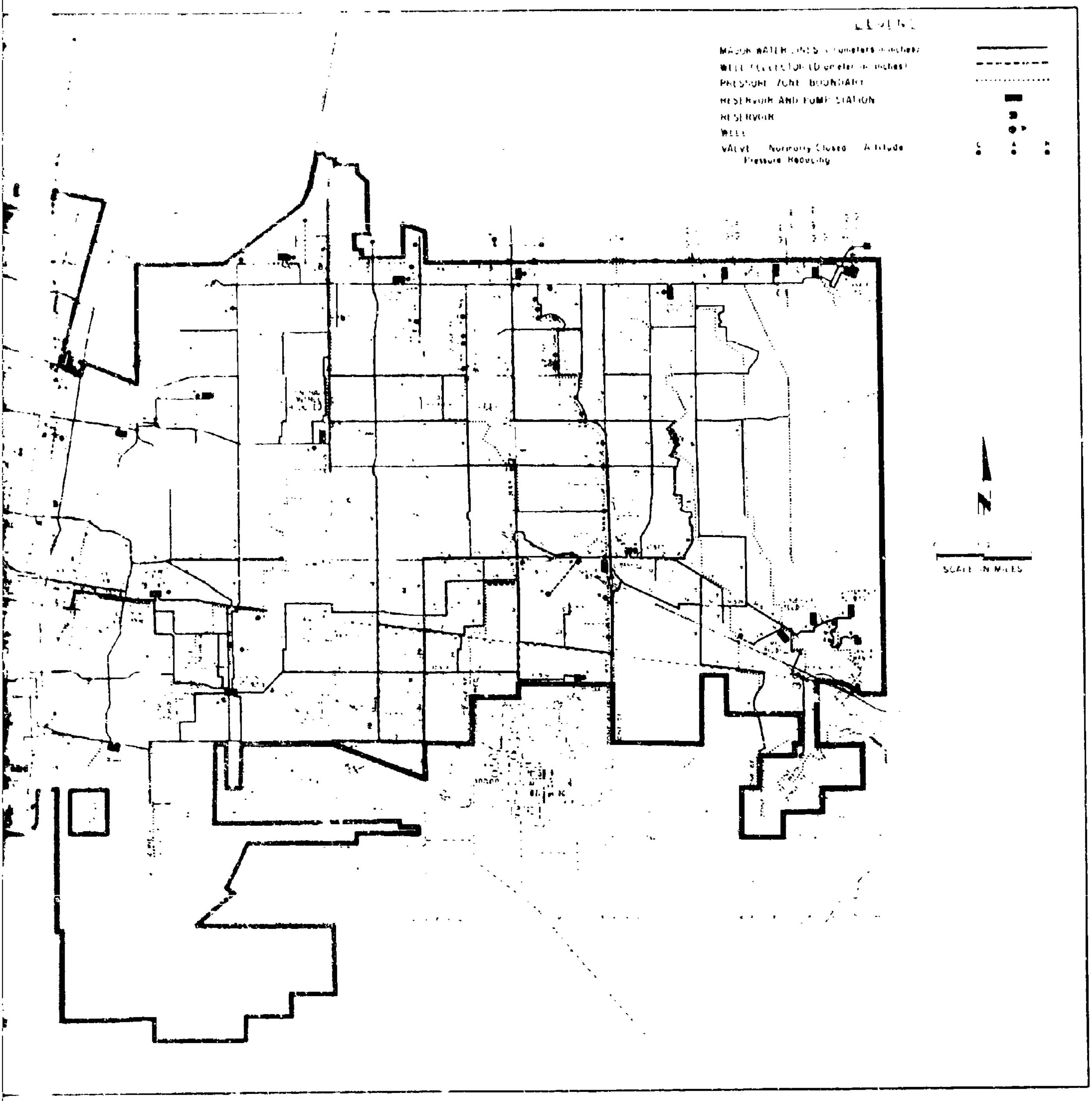


FIGURE 3 ALBUQUERQUE WATER SYSTEM

2

flow back to the lower pressure zones through pressure reducing valves during periods of high demand.

There is a small zone at the eastern edge of the service area with no storage, which depends entirely on booster station supply. There is also a small area in the southwestern portion of the city with a completely separate system.

Wells

The water supply for Albuquerque is from 68 wells, ranging in depth from 65 feet to 1,300 feet. Casing sizes range from 14 inches to 18 inches. These wells are identified in thirteen well fields with two or more wells, and two sites with single wells. In some cases, this grouping is somewhat arbitrary as the wells apparently all draw from a common Rio Grande basin aquifer. The water table varies from five or ten feet below ground surface in the lowlands to about 600 feet in the highest lands to the east.

The total theoretical production capacity of the 68 wells is about 98,500 gallons per minute (gpm) or a little over 140 million gallons per day (mgd). However, on a sustained basis, it is more reasonable to assume that only about 75 percent of this production can be maintained. This indicates a sustained rate of 74,000 gpm or 108 mgd.

Well pumps are all of the deep well turbine type and most of them are placed inside the pump houses. The valves are all either in the pump houses or in covered vaults and the electrical controls are all inside the pump houses. The pump houses are brick or concrete block at the newer installations and corrugated metal at most of the older ones. Representative pictures of three types of well pump houses are shown in Figure 4.

The well pumps are all powered with electric motors and none of them have alternatives in case of a power failure. The motors are designed for voltages ranging from a minimum of 240-440 volts to a maximum of 4160 volts. Transformers are located on outside ground pads at a few sites and are located either inside the buildings or on outside poles at most sites. All of the power lines to the sites are pole mounted. The various well sites are shown on Figure 3 and the production capacities are listed in Table 1. Descriptions of the equipment are given in Appendix A.

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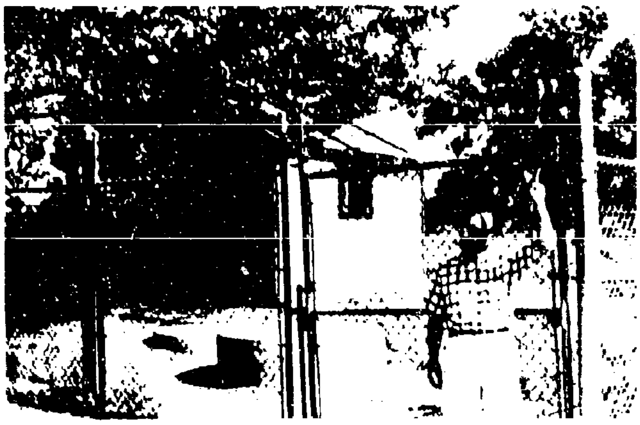
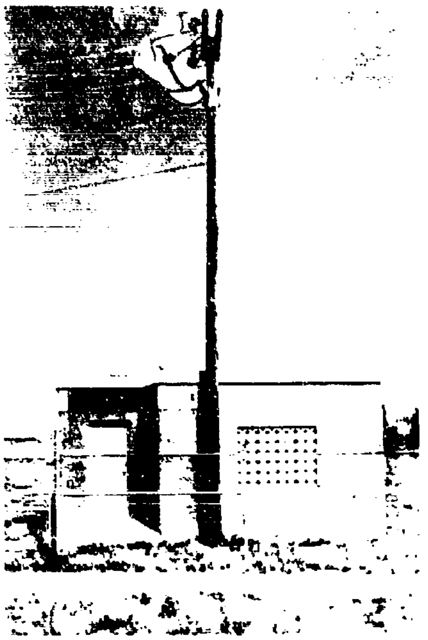


WOOD SHELTER
Atrisco Well No. 7



MASONRY SHELTER
Thomas Well No. 3

SHEET METAL SHELTER
Atrisco Well No. 11

FIGURE 4 TYPICAL WELL PUMP SHELTERS

Table 1

ALBUQUERQUE WELL FACILITIES*
August 1965

Well Field	Number of Wells	Total Production Capacity (gallons/minute)[1]
Atrisco #1	3	3,400
Atrisco #2	8	4,450
Burton	3	5,700
Candelaria	4	3,300
Duranes	7	12,900
Griegos	5	9,870
Leyendecker	4	9,400
Lomas	1	1,500
Love	5	7,000
Main Plant	7	4,900
Ponderosa	1	325
San Jose	6	8,050
Thomas	4	6,500
Volandia	6	18,100
Valley Gardens	2	750
West Mesa	2	2,250
Total	68	98,395

* Information from Ref.1, and from Albuquerque Water Division, July 1968.

Water Treatment

Water from the wells is pumped through collector pipelines to the primary reservoirs, where it is automatically chlorinated before entering the reservoir. Any sand that is pumped is allowed to settle in these reservoirs before boosting into the distribution system. There is no other water treatment used.

About one week's supply of chlorine is usually available at each chlorination point. Chlorine is delivered by a local supplier under contract. The supplier obtains liquid chlorine in tank cars and makes daily deliveries in 150 pound cylinders as needed at the various sites. There is normally at least one full tank car (30 tons) on hand. The supplier also normally has some chlorine in other forms on hand as follows:

Dry chlorine (70 percent) 30,000 to 40,000 pounds

Liquid bleach (10 percent) 1,000 to 2,000 gallons

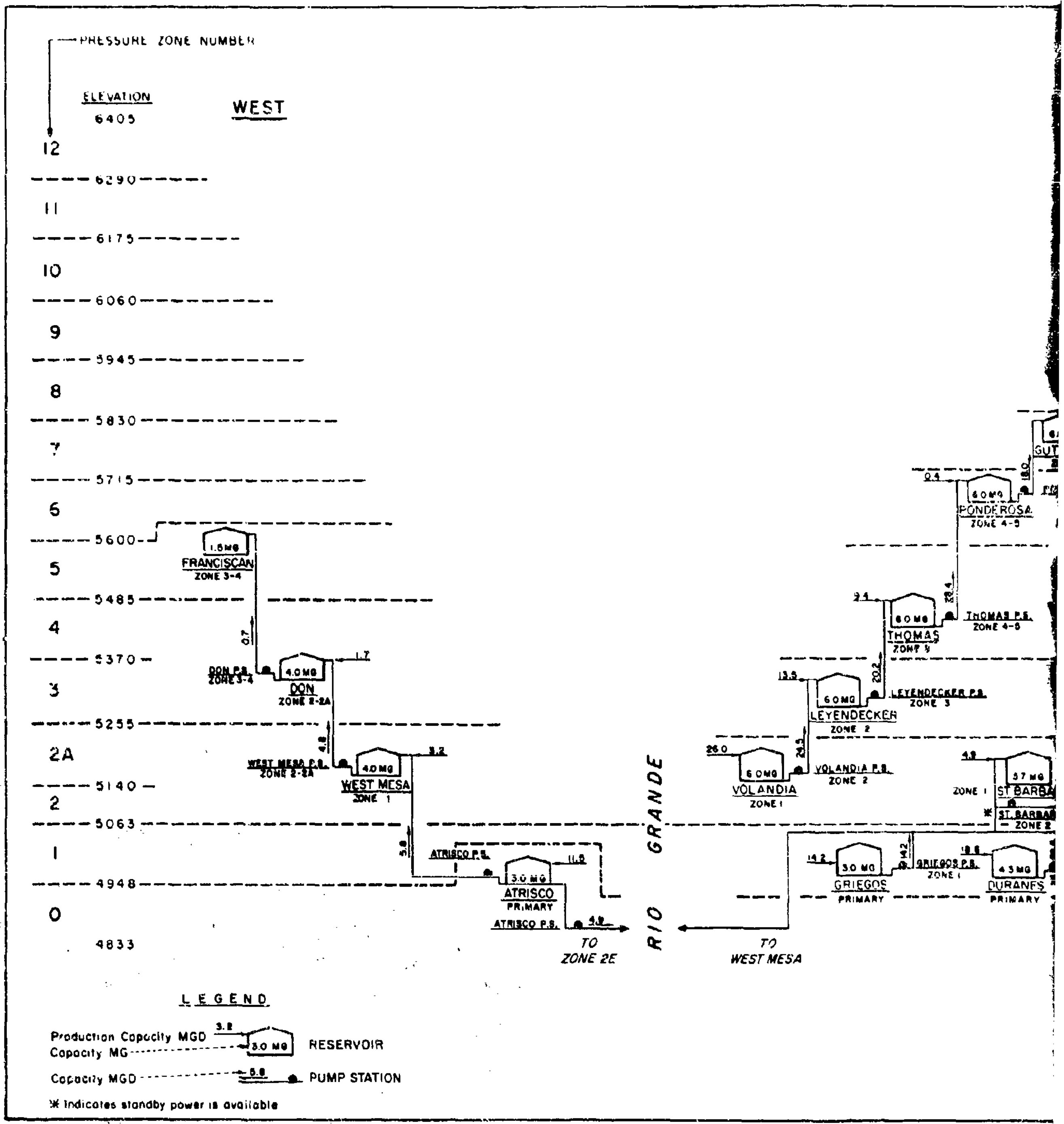
Booster Pumps and Storage

Several of the primary reservoirs used to receive water from wells also are used as storage and distribution reservoirs for the lower areas of the city. In many cases, the water is re-lifted through booster pumping stations into higher pressure zones, either to meet current demands or for storage in other reservoirs.

The Albuquerque water system is divided into pressure zones roughly parallel to the Rio Grande River, and successively higher toward the mountains. The differential between zones is about 115 feet in most cases, but there is one interval of about 80 feet on the west side and two of about 150 feet on the east side.

Distribution is separated into three pressure zones on the west side, with some storage located in a fourth, higher zone. Distribution on the east side is divided into nine pressure zones, with storage located in eight zones. The highest zone on the east side is served by a booster pumping plant with no storage reservoir.

The pressure zones are shown schematically on Figure 5 and are delineated on the map of Figure 3.


PRESSURE ZONE NUMBER
ELEVATION
WEST
6405
12
6290
11
6175
10
6060
9
5945
8
5830
7
5715
6
5600
5
5485
4
5370
3
5255
2A
5140
2
5063
1
4948
0
4833
1.6MG
FRANCISCAN
ZONE 3-4
0.7
DON P.S.
ZONE 3-4
4.0MG
DON
ZONE 2-2A
1.7
4.8
WEST MESA P.S.
ZONE 2-2A
4.0MG
WEST MESA
ZONE 1
3.2
5.8
ATRISCO P.S.
3.0MG
ATRISCO
PRIMARY
11.5
ATRISCO P.S.
4.9
TO
ZONE 2E
RIO GRANDE
TO
WEST MESA
26.0
6.0MG
VOLANDIA
ZONE 1
24.5
VOLANDIA P.S.
ZONE 2
13.5
6.0MG
LEYENDECKER
ZONE 2
20.2
LEYENDECKER P.S.
ZONE 3
9.4
6.0MG
THOMAS
ZONE 4
28.4
THOMAS P.S.
ZONE 4-5
0.4
6.0MG
PONDEROSA
ZONE 4-5
18.0
GUT
14.2
3.0MG
GRIEGOS
PRIMARY
14.2
GRIEGOS P.S.
ZONE 1
18.6
4.3MG
DURANES
PRIMARY
4.9
5.7MG
ZONE 1
ST. BARBA
ST. BARBAR
ZONE 2
LEGEND
Production Capacity MGD
Capacity MG
3.2
3.0MG
RESERVOIR
Capacity MGD
5.8
PUMP STATION
✱ Indicates standby power is available

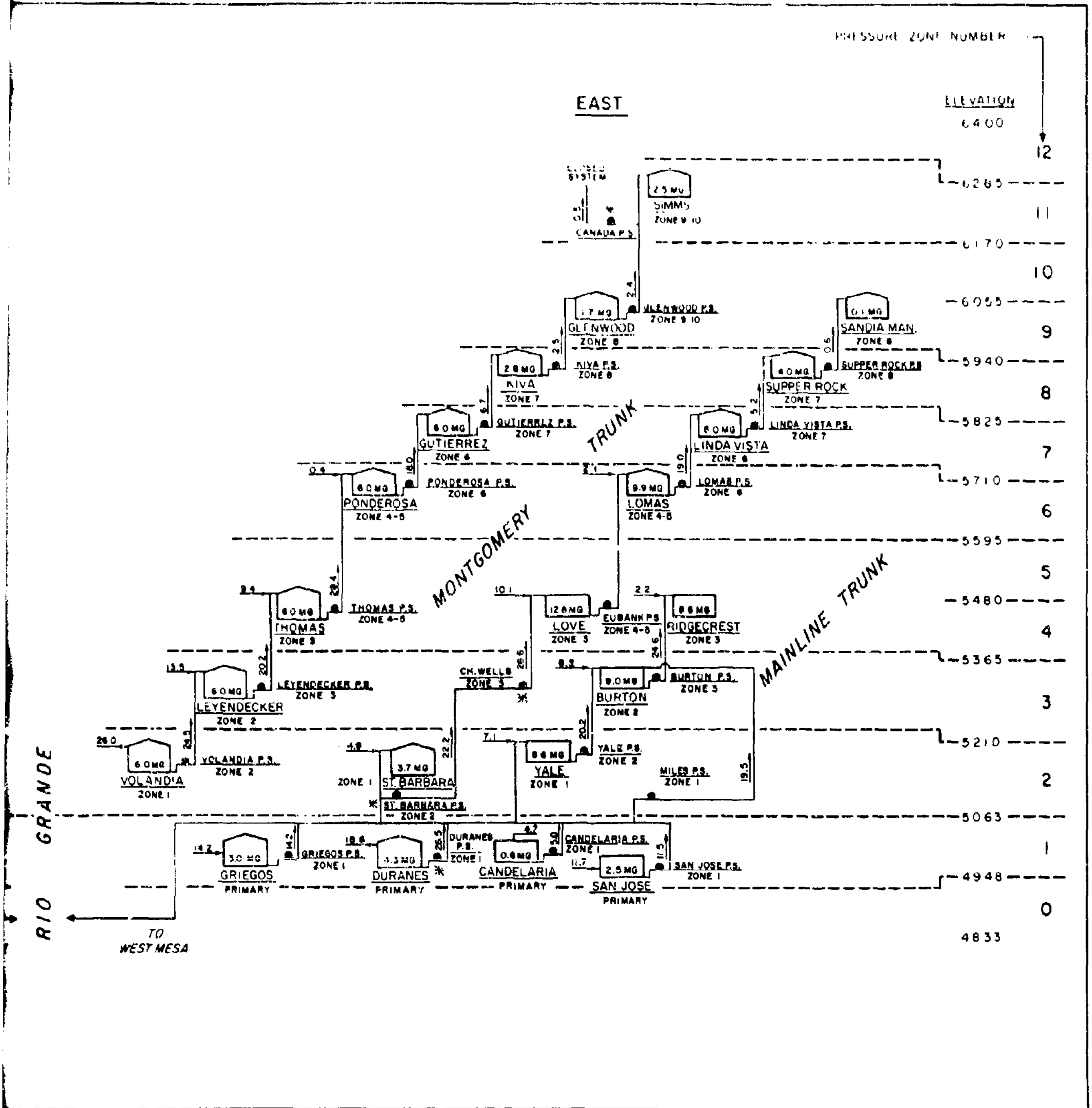


FIGURE 5 ALBUQUERQUE WATER SYSTEM VERTICAL SCHEMATIC

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There are 26 booster pumping stations in the general system which provide for lifting water from each of the lower zones into the next higher one, and for transferring water from one side of the river to the other. Four of the 26 booster stations have two pumps each that are equipped with gas-fueled auxiliary engines. A 27th booster station serves a small area that is not interconnected with the general system. Equipment descriptions are given in Appendix A.

Most of the plants are sheltered in masonry buildings, but there are several in sheet metal structures and three in reinforced concrete structures. The location of these stations are shown on Figure 3 and their relation to the system is shown on the schematic diagram of Figure 5. The pumps and capacities at each station are listed in Table 2. Typical pump house structures are shown in Figure 6.

The reservoirs in the Albuquerque water system are, in general, set to maintain normal pressures in the zones they serve between 50 pounds per square inch (psi) and 100 psi, although during heavy fire flows the pressure in some areas may drop to as low as 20 psi.

The 30 reservoirs are all ground storage types, and construction methods include circular and rectangular shapes of reinforced concrete, prestressed concrete and steel. The total storage capacity is about 113 million gallons. Table 3 gives information on the reservoir types and capacities and the zones that they serve. Reservoir locations are shown on Figure 3 and their relation to the total system is shown on the schematic of Figure 5. Photographs of typical reservoirs are shown in Figure 7, and descriptions of all reservoirs are given in Appendix B.

Normal operating procedures in Albuquerque call for retaining the lower eight feet in each reservoir for emergency fire supply.

Transmission and Distribution

The water transmission and distribution system in Albuquerque includes about 900 miles of pipelines, ranging from a maximum diameter of 42 inches to a minimum of 3/4 inches in some of the older parts of the system. There is no list available for the footages by sizes and types of pipe in use in August of 1965, but a tabulation as of February, 1968 is shown in Table 4.

The transmission works on the west side consist of a single system with booster pumps for transmission of water from the lower pressure zones to the higher zones, and pressure reducing valves to return stored

Table 2

ALBUQUERQUE BOOSTER PUMPING FACILITIES*

August 1965

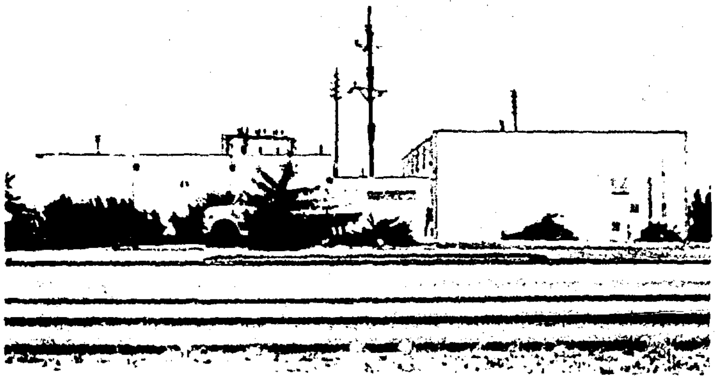
Pumping Station	Number of Pumps	Total Capacity (gallons/minute)
Atrisco #1	2	3,400
Atrisco #2	4	4,000
Burton	6	17,100
Canada	4†	330
Candelaria	2	3,500
Charles Wells	5†	19,900
Don	2	530
Duranes	4†	18,400
Eubank	6	24,000 (est)
Glenwood	2	1,650
Griegos	3	9,870
Gutierrez	2	4,680
Kiva	2	1,760
Leyendecker	4	14,000
Linda Vista	2	3,600
Lomas	5	13,200
Main Plant	2	4,900
Miles (Atrisco leg)	2	9,500
Ponderosa	3	12,500
Santa Barbara	5†	15,400
San Jose	4	8,000
Supper Rock	2	400
Thomas	3	19,700
Valley Gardens	4	970
Volandia	4	17,000
West Mesa	4	3,400
Yale	4	14,000
Total	92	

* Information from Reference 1, and from Albuquerque Water Division Personnel July, 1968

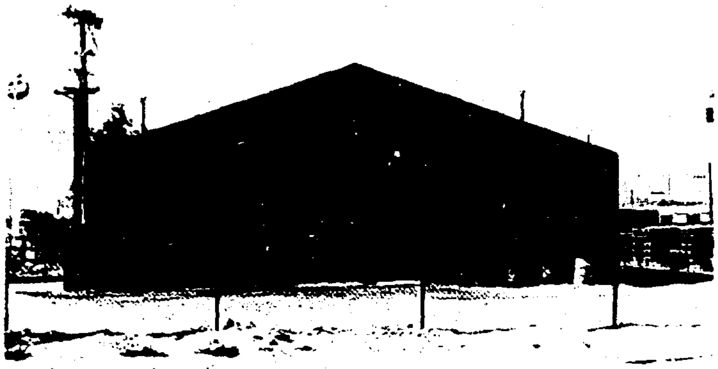
† These stations have auxiliary, gas-powered engines on some pumps:

Station	Number of Pumps	Capacity
Canada‡	2	325 gpm each
Charles Wells	2	3,500 gpm each
Duranes	2	2,800 gpm each
Santa Barbara	2	2,800 gpm each

‡ This station apparently only uses one pump at any given time, and has one electrically-driven and two gas-powered pumps as standby.



MASONRY SHELTER
Eubank Pump Station



SHEET METAL SHELTER
Santa Barbara Pump Station

REINFORCED CONCRETE SHELTER
Yale Pump Station

FIGURE 6 TYPICAL BOOSTER PUMP SHELTERS

Table 3

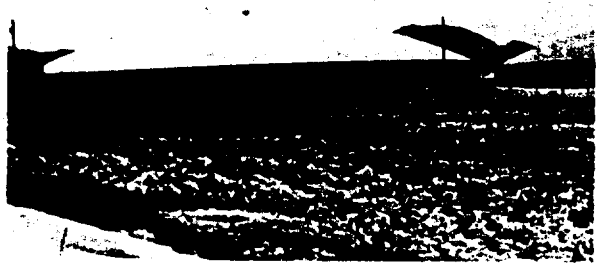
ALBUQUERQUE WATER STORAGE FACILITIES[*]
August 1965

Pressure Zone Name	Construction	Capacity (gallons)	Storage by Zones (gallons)
Isolated System			
Valley Gardens	Steel	500,000	500,000
Primary West			
Atrisco #1[†]	Rectangular concrete	81,000	
Atrisco #2[‡]	Steel	3,000,000	3,081,000
Zone 1W			
West Mesa	Prestressed concrete	4,005,000	4,005,000
Zone 2W			
DON reservoir	Steel	4,030,000	4,030,000
Zone 3W			
Franciscan	Steel	1,529,000	1,529,000
Primary East			
Candelaria	Steel	620,000	
Duranes	Prestressed concrete	4,286,000	
Griegos	Steel	3,000,000	
San Jose	Steel	2,500,000	10,406,000
Zone 1E			
Volandia	Steel	6,000,000	
Yale	Rectangular concrete	8,062,000	14,062,000
Zone 2E			
Burton	Rectangular concrete	3,033,000	
Burton	Circular concrete	6,000,000	
Leyendecker	Steel	6,001,000	15,034,000
Zone 3E			
Ridgecrest #1	Circular concrete	2,612,000	
Thomas	Steel	6,051,000	
Love	Rectangular concrete	3,367,000	
Love	Rectangular concrete	3,367,000	
Love	Prestressed	6,000,000	21,397,000
Zones 4E & 5E			
Lomas	Circular Pritzger concrete	6,000,000	
Lomas	Prestressed concrete	3,985,000	
Ponderosa	Steel	6,027,000	16,012,000
Zone 6E			
Gutierrez	Steel	6,003,000	
Linda Vista	Steel	5,958,000	11,961,000
Zone 7E			
Kiva	Prestressed concrete	2,820,000	
Supper Rock	Steel	4,014,000	6,834,000
Zone 8E			
Glenwood Hills	Prestressed concrete	1,700,000	
Sandia Manor	Steel	125,000	1,825,000
Zones 9E & 10E			
Simms	Prestressed concrete	2,520,000	2,520,000
Total Storage			113,196,000

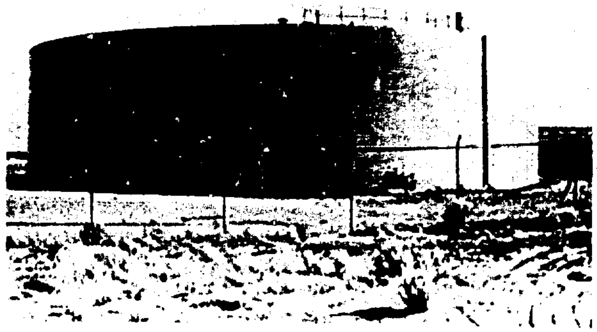
[*] Information from Ref. 1, and from Water Division personnel, July 1968

[†] Settling basin

[‡] Atrisco #2 serves Zone 2E



"PRITZGER" CONCRETE
Lomas Reservoir



STEEL
Don Reservoir

PRESTRESSED CONCRETE
Simms Reservoir

REINFORCED CONCRETE
Yale Reservoir

FIGURE 7 TYPICAL RESERVOIRS

Table 4

ALBUQUERQUE WATER SYSTEM PIPELINES
February 1968
(feet)

Diameter In Inches	Galvanized Steel	Steel	Wrapped Steel	Cast Iron	Ductile Steel	Asbestos Cement	Steel Cylinder	Concrete Cylinder	Total
3/4	1,300								1,300
1	2,500	500							3,000
1-1/4		12,240							12,240
1-1/2		17,120							17,120
2	15,234	46,143							61,377
2-1/4	1,680	21,290		46,750		720			70,440
4		346,927	16,930	141,100		18,780			523,737
5		87,313							87,313
6		485,425		1,774,038		419,047			2,678,510
8		73,055		208,335	3,800	13,985	14,440		313,615
10		55,560		71,950	20,450	11,700	18,540		178,200
12		39,392		254,895	11,860		5,750	12,150	324,047
12-3/4		800							800
14		10,880		33,920					44,800
16		47,305		93,825	810		6,550	48,900	197,390
18		3,025		24,010				5,100	32,135
20		46,040		75,175	1,900		14,990	13,065	151,170
22		12,750					6,995		19,745
24		24,150		65,205	2,700		5,870	40,600	138,525
30				39,406				13,825	53,231
36		850		31,312				45,175	77,337
42								11,340	11,340
Total	20,714	1,330,765	16,930	2,859,921	11,520	464,232	73,135	190,155	4,997,372

water during times when the demand in the lower zones exceeds production. The transmission works on the east side is similar except that, due to the larger area served, the system is divided into two major trunk lines with interties between them at several points. There are two pipelines for transfer of water across the river. One small service area is served by a separate well, booster and reservoir system and is not interconnected with the rest of the distribution system.

Figure 3 shows the locations of major pipelines and Figure 5 illustrates schematically the relationship of the various system components.

Valves and Controls

The water system is extensively equipped with automatic controls and motor operated valves at critical points to control well pumps and booster equipment dependent upon system pressure conditions. However, the automatic equipment and motor-operated valves can all be operated manually if necessary.

System pressure conditions are also monitored at the central control building and provision is made for remote control of some critical operations. The central control installation also includes a standby generator to provide emergency electrical power for equipment within the building. A photograph of the central control building is shown on Figure 8. Most street intersections are equipped with two gate valves, but there are some with three, and some with only one. All of these valves are located underground, with cast iron or steel covers on the access vaults.

Fire Hydrants

Fire hydrants throughout the system are of the "dry barrel" type and are generally spaced at 500 foot intervals or at intersections.

Services

Water consumption in the Albuquerque water system is principally domestic. The city has relatively little industrial development, and commercial uses represent a small part of the total. Because most of the water is delivered through typical domestic services, the most significant damage which occurs to terminal distribution facilities will be that which occurs to those domestic services.

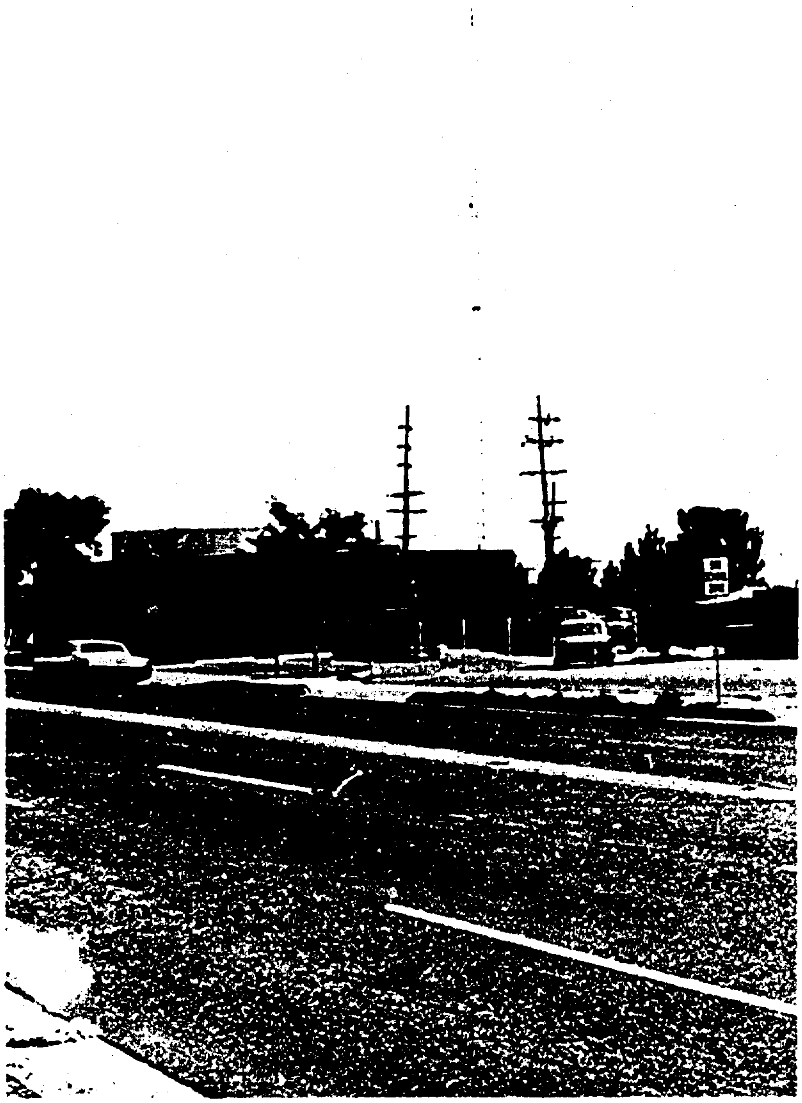


FIGURE 8 CENTRAL CONTROL BUILDING AND RADIO ANTENNA

There are no data available on the numbers of services within the various pressure zones. However, the Albuquerque Water Division does have figures on the total water use during 1965, and have calculated that the city wide average water use for the year was 175 gallons per capita per day (gcd), and that there was an average of 4.18 persons per service connection. This indicates a total of 62,240 services in 1965.

Another Division report shows a total of 62,140 meters in service on July 19,1965, when the peak daily consumptions for that year occurred. This figure and the approximate distribution of housing units by census tracts have been used to develop an estimate of the density of services in the various zones of the service area. This analysis is presented in a later section of this report.

People Target Model

The Water Division is divided into three sections: engineering; operations; and maintenance and construction. The total personnel in August,1965 was a little over 130. Many positions within these groups, especially in operation, involve business matters and clerical, stenographic and secretarial support that is not relevant to the capability for operation under emergency conditions. Personnel in positions critical to postattack operations totalled as follows:

Engineering	17
Operations	19
Maintenance and Construction	47
TOTAL	83

Engineering personnel work in the Division offices at Fourth and Marquette; Operations personnel, some of whom are on call 24 hours per day, work out of the Central Control Building at 2629 San Mateo Blvd, N.E. Maintenance and Construction personnel work out of the City Yard at 923 Broadway N.E. (Figure 3). Residences of engineering and operations personnel are rather uniformly distributed throughout the City, but maintenance and construction personnel tend to live mostly in the areas west of the AT&SF railroad.

System Target Model

The system target model includes facilities and personnel which, although not a part of the water system, may effect its operation if they are damaged or injured.

Supplies and Equipment

All supplies, tools, equipment and vehicles are stored at the City Yard. However, vehicles assigned to operations personnel who are on duty or on emergency call during evening or night-time hours will be dispersed throughout the area.

Supplies on hand at the City Yard normally include enough clamps, fittings, valves, and so forth, for about 90 days operation. Vehicles and major equipment items as of August 1965 are listed in Table 5. Normal gasoline consumption averaged about 6,000 gallons per month.

Communications and Controls

All Water Division vehicles are equipped with two-way radios. The base radio station is located at the Central Control Building (Figures 3 and 8) and remote transmitters, operated through the base station antenna, are located at the Water Division office downtown and at the City Yard.

Remote sensing devices and remote controls in the water system are operated through the public telephone utility. Post attack operation of these facilities may depend not only on the direct damage, but also on general property and people damage to the telephone system.

Electric Power Supply

The normal power supply for the Albuquerque water system is from the electrical distribution system of the Public Service Company of New Mexico. There is no alternative source of power for any of the wells, and gas powered engines for standby power are provided at only four of the twenty-seven booster pumping stations, involving only eight of the ninety-two pumps. The power transmission and distribution system is all pole mounted with the exception of a few major downtown buildings; all of the water facilities are supplied via pole-mounted conductors.

Table 5

VEHICLES AND MAJOR EQUIPMENT*
August 1965

Type of Equipment	Number Available Pre-Attack
Sedan	9
Cabin Chassis (2 ton)	4
Pickup (1/2 ton)	18
Pickup (3/4 ton)	10
Crew Cab (2 ton)	1
Stake Truck (1-1/2 ton)	1
Cabin Truck (1-1/2 ton)	1
Utility Truck (2-1/2 ton)	1
Dump Truck (2 ton)	3
Carryall (1/2 ton)	1
Stake Truck (1/2 ton)	2
Total Vehicles	51
Pipe Trailer	1
Air Compressor	4
Special Trailer	2
Tractor with Hoist	1
Rubber-tired Loader	2
Back Hoe	2
Ditch Digger	2
Tractor	1
Concrete Saw	1
Special Equipment	2
Total Construction Equipment	18

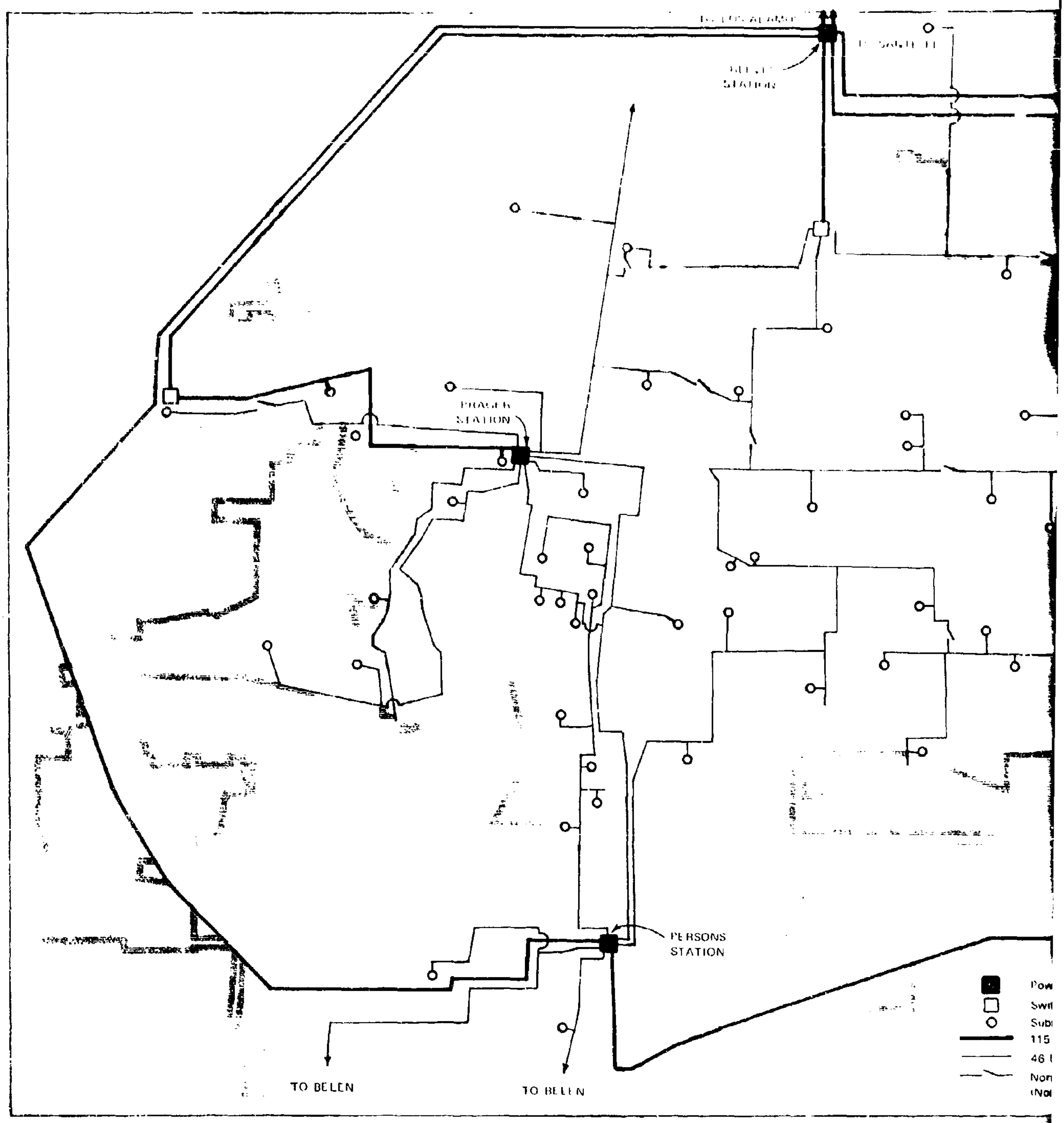
* Information from Reference 1. Some 1966 and 1967 model vehicles were included, but it was assumed that these replaced older comparable equipment available in August, 1965

Transformers for the stations are located on poles in many cases, on outside pads in a few cases and inside the building in a number of cases, particularly at the newer stations.

There are three power generating stations at Albuquerque. Reeves Station with a net capability of 174,000 kva and Persons Station with 114,000 kva are the basic local power sources. Prager Station, with a capability of 31,400 kva is used primarily as a standby source. The Albuquerque power system is interconnected to the cities of Belen and Santa Fe by 44 kv lines, and a 115 kv line encircles Albuquerque and connects to Santa Fe and Las Vegas. Figure 9 shows the major components of the power system.

Operations

The total water system target model includes the property and personnel of the water division, but also includes property and personnel of other systems to the extent that their impairment might interfere with the operations of the water facilities. The effects of personnel casualities depend not only on the percentages involved, but also on the special responsibilities and skills of the individuals. Operation of the water system will also depend somewhat on the availability of supplies and equipment essential to direction and execution of the repair work, and the assimilation of information regarding the system.


PRAGER STATION
PERSONS STATION
TO BELEN
TO BELEN
115

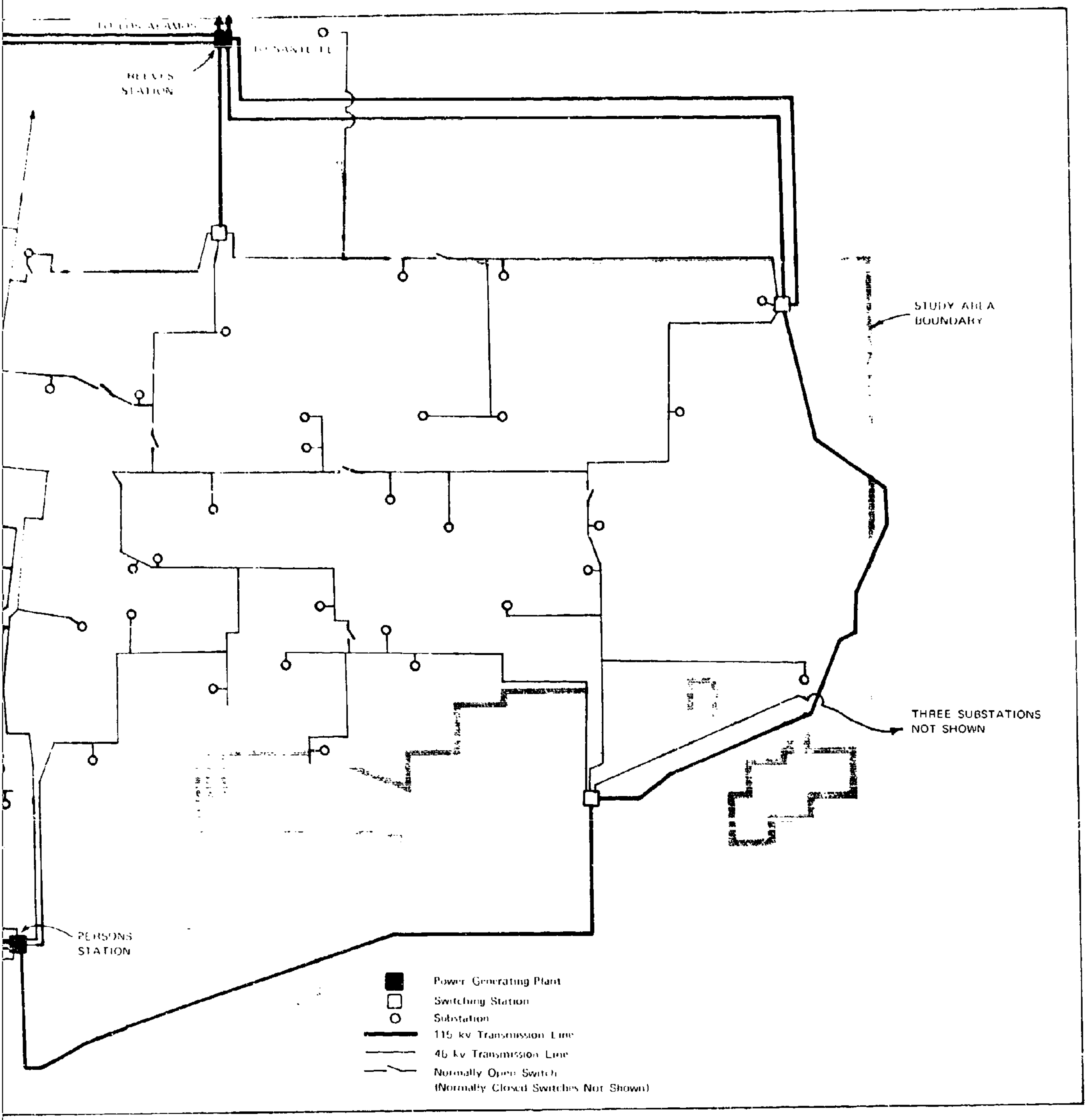


FIGURE 9 MAJOR COMPONENTS OF ELECTRICAL POWER NETWORK

2

III CIVIL DEFENSE POSTURE
(Posture Spec.)

Pre-Attack Scenario

The Attack Preparation Scenario[6] indicates that as early as March, 1965, the diplomatic situation between the western allies and the iron-curtain countries is deteriorating and a tense military situation is developing in West Germany. This situation, however, does not result in greatly increased civil defense activity in Albuquerque, or greatly increased public interest in civil defense until late June.

On June 25, the New Mexico State Civil Defense Director notifies Albuquerque of a military declaration of Defense Condition #3 (Defcon 3). This results in increased official action in Albuquerque, but little response from the news media or the public. By June 28, however, the news media and the public are much more aware of the local implications of the international situation and by June 29, the Federal Government has declared the highest state of defense readiness, and Albuquerque officials decide to institute a crash construction program to alleviate a shortage in shelters.

The President announces orders for military mobilization on July 7, as an undeclared war is already in progress. Locally, all measures for construction and stocking of shelters, training of emergency personnel, and instruction of the public are proceeding on a crash basis. The news media are diligently publicizing civil defense information.

Shelter managers are put on full-time duty on August 23, and there is heavy, but orderly buying of supplies by the public. A few people are leaving the City. The general public, as well as the officials are well aware that a nuclear attack is probable.

On Tuesday, August 24 at 1922, the New Mexico State Police District Headquarters in Albuquerque announces an air raid warning and that enemy missiles have been detected heading toward North America. A nuclear burst occurs over the southeast edge of Albuquerque at 2113 hours.

Albuquerque Shelter Plan

Albuquerque had existing shelter space for 234,000 persons as of early June, 1965.[5] This space was provided for some people outside the study area in Bernalillo County as well as within the city, and included 165,000 spaces in categories 2 to 8 and 69,000 spaces in category 1.

The city administration had plans for mobilizing Public Works personnel and equipment and local contractors to construct additional capacity for 100,000 persons, designed to meet category 2 specifications. In the Albuquerque attack preparation scenario,[5] it was assumed that this construction was completed between June 28 and August 21, so that there would have been shelter space for every person in the study area within 30 minutes travel time of their place of residence.

Water System Emergency Plan

No detailed water system emergency plan had been formulated for Albuquerque, but the division management has indicated that it would have recorded the assigned shelter locations for all personnel and would have stressed the great importance of all off-duty personnel reaching their assigned shelters. In addition, all vehicles not in use would have been dispersed in charge of off-duty personnel.

The plan would have been to distribute the vehicles as nearly as possible around the periphery of the City and to assure that each vehicle was well equipped with tools and supplies.

IV ATTACK ENVIRONMENT MODEL
(AE Mod. Spec.)

Hypothetical Nuclear Attack

The Albuquerque area is assumed to be affected by five nuclear bursts.[8] One of these, Number 173, has been assumed to be an air burst over Sandia Base, and subjects the study area to air blast overpressures and the resulting ground shock, as well as thermal radiation. The assumed ground zero is assumed about 1,500 feet north and 200 feet east of the southwest corner of Section 34, Township 9 north, Range 4 east.

The other four bursts occur at some distance from Albuquerque but result in radioactive fallout due to the wind movement. Table 6 shows the hypothetical weapons and the assumed times of detonation.

Table 6

HYPOTHETICAL WEAPONS NEAR ALBUQUERQUE
August 24, 1965

Weapon Number	Time of Burst (mountain standard time)	Yield (kilotons)	Type of Burst
173	9:13 p.m.	5,000	(air-14,500 ft elevation)
195	9:36 p.m.	5,000	ground
204	9:45 p.m.	5,000	ground
209	9:50 p.m.	5,000	ground
210	9:52 p.m.	5,000	ground

Blast and Shock $\left(\frac{\text{C A E}}{\text{op, dp, gs}}\right)$

The air burst of Weapon No. 173 would result in peak overpressures of more than 20 pounds per square inch (psi) within a small area near ground zero, and peak overpressures of 2 psi or greater throughout

essentially the entire study area.[7] The approximate distribution of theoretical pressures is as follows:

Peak Overpressure	Percentage of Area
2 psi or greater	essentially 100 percent
3 psi or greater	about 80 percent
5 psi or greater	more than 60 percent
10 psi or greater	more than 25 percent

The theoretical overpressure distribution is shown on Figure 10.

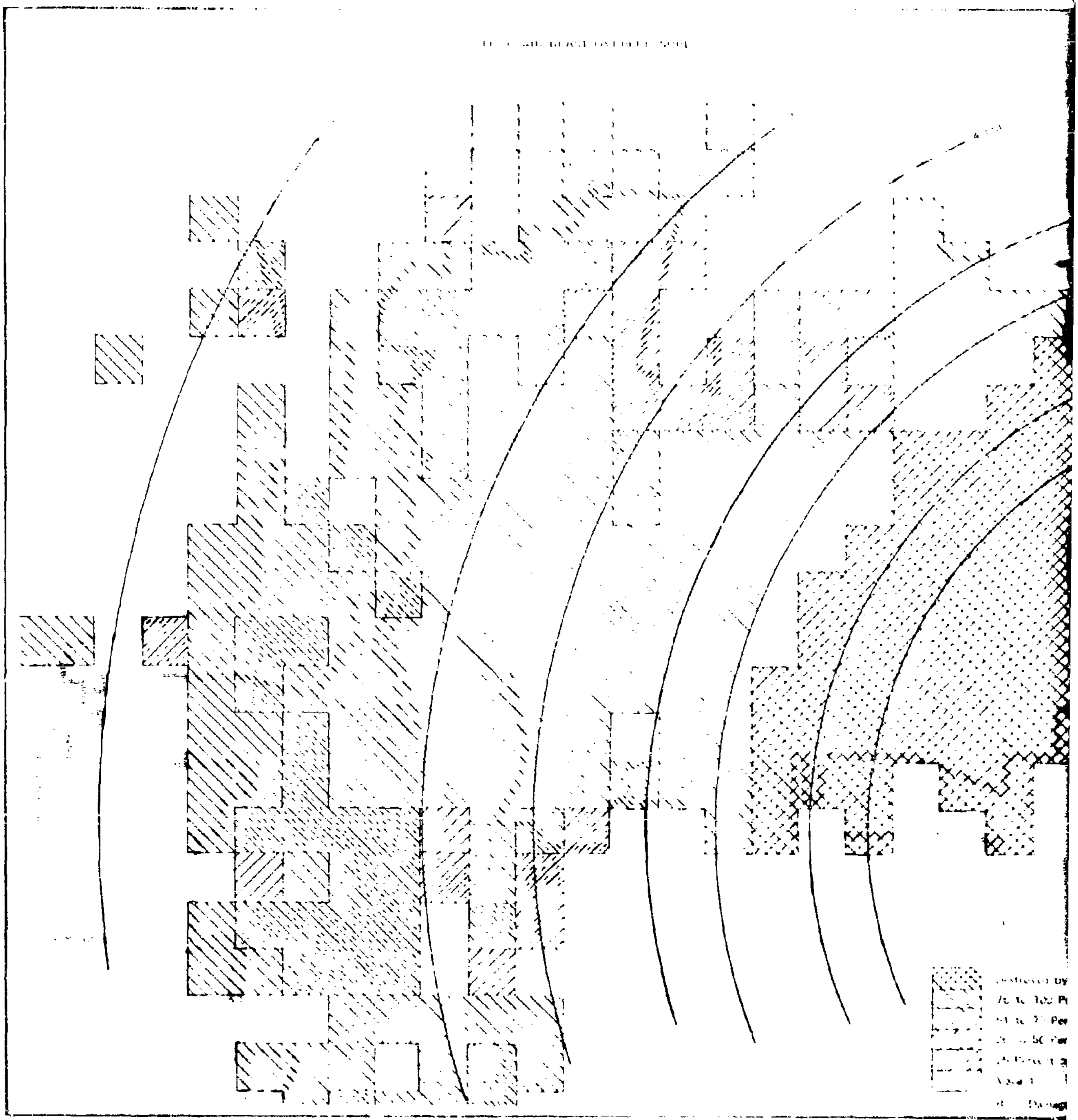
There will be essentially total destruction of facilities in the higher pressure zones and some damage over most of the city.

It has been predicted[8] that the ground shock induced by the air blast would cause maximum particle accelerations in excess of 10 g (both vertical and horizontal) out to more than 10 kilometers from ground zero. The particle displacements predicted at this same range are about 1.5 inches in the horizontal direction and 3.0 inches in the vertical direction. Presumably then, these values will be exceeded over more than 50 percent of the study area, and include all of the region where peak airblast overpressure exceeds about 5.8 psi. (See Figure 10)

Piping which connects buried pipelines (which will move essentially in phase with the ground motion) to above ground structures (which may respond quite differently) is quite likely to be ruptured, even in cases where the above-ground structure is not seriously damaged. This aspect is likely to be particularly important in the case of reservoirs, where the airblast might not seriously damage the tanks, but differential motion might rupture the connections to the tank sides or bottoms.

<u>Thermal Pulse and Fire</u> $\left(\frac{C\ A\ L}{tp,\ f,\ b}\right)$

The detonation of Weapon No. 173 would result in a thermal energy input between 10 and 12 calories per square centimeter at the furthest limits of the study area,[2] and would cause several times this much near ground zero. Even the above minimum thermal radiation levels would be sufficient to ignite some materials such as punky wood and some kinds of paper waste and dry leaves.[10] Although some recent studies indicate that the actual igniting effects of nuclear bursts are not as great as would be expected from a theoretical analysis,[11] it must be expected that many



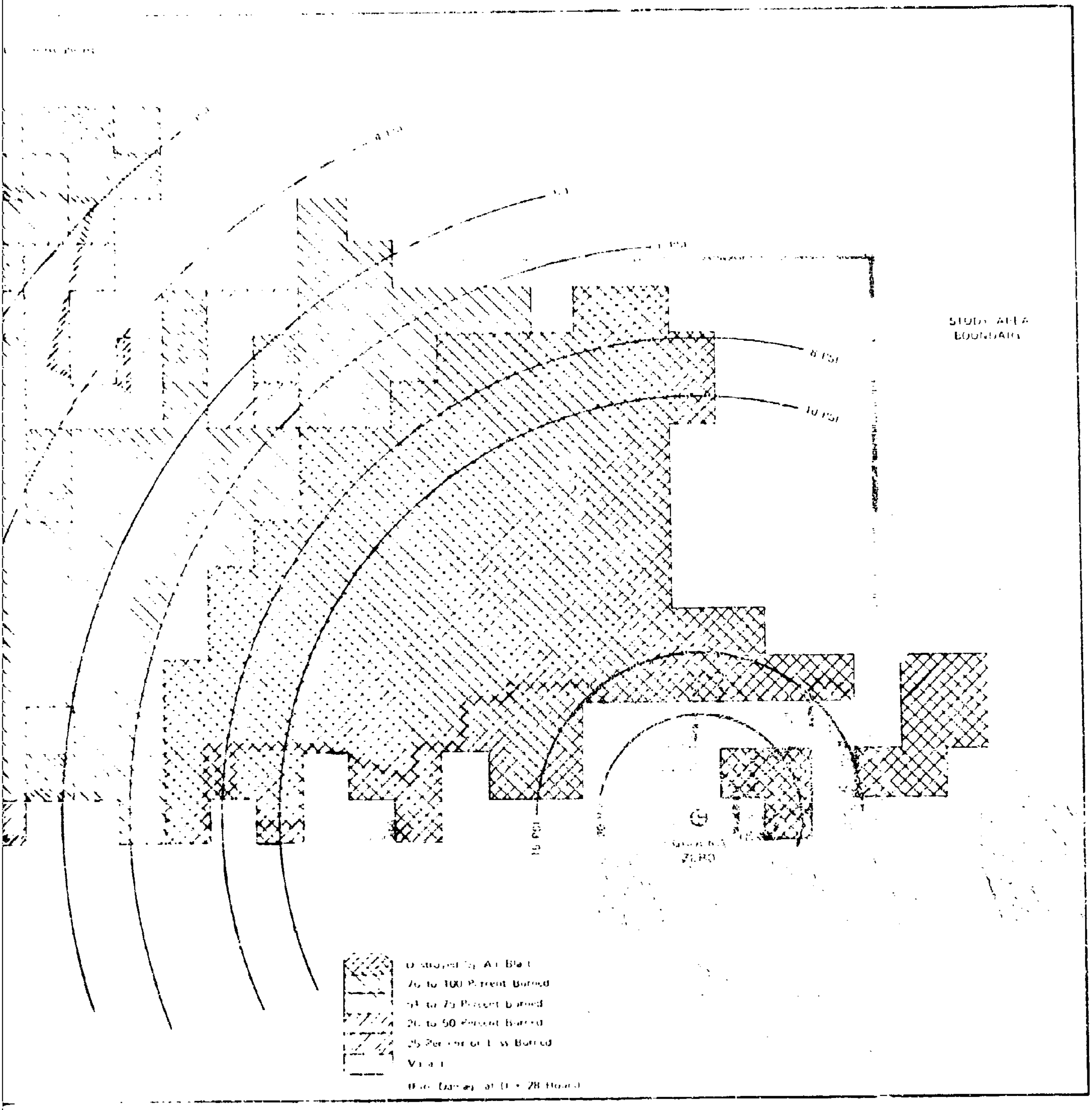


FIGURE 10 PEAK AIR BLAST OVERPRESSURE AND SUBSEQUF IRE DAMAGE

2

fires would be started in the areas close to ground zero and that some fires would result even at the extreme distances.

The areas of the highest incidence of fires would also be areas of extreme building and utility damage, so that control of fires would be hampered by lack of usable equipment, lack of competent personnel and lack of water. It would also be difficult in some areas to move personnel and equipment to the fires because of debris in the streets.

Albuquerque in general has rather wide spacing between buildings, and has relatively wide streets. There is also relatively little debris producing vegetation and there are few tall buildings. The city is also divided by firebreaks formed by the Rio Grande River, the railroads, and the freeways.

The above factors indicate that a city-wide destruction by fire is not inevitable, but it can be expected that some areas would be burned out rather completely, and that postattack fire control measures would be essential in most areas. Lacking fire control capability, the destruction by burning could be very widespread.

Initial and Residual Radiation $\left(\frac{C\ A\ E}{ir,\ rr}\right)$

The initial radiation will have no significant effect on the water system except for injuries to personnel not in shelter at the time of detonation. This factor has been considered in the Dikewood casualty estimates,[12] which are used for calculation of personnel damage (CHD).

Radioactive debris from Weapon No. 173 would be carried away from Albuquerque due to the height of burst (14,500 feet elevation) and the wind movement, but fallout from the other bursts would arrive at about 10:30 a.m. August 25,[13] or about 13 hours after the burst of Weapon No. 173. Due to the locations of the other bursts relative to Albuquerque, and to the wind conditions, it has been predicted that a peak intensity of 18 to 22 roentgens per hour would be reached by about 2:00 p.m. August 25, decaying to less than 1 roentgen per hour by August 31. This would be fairly uniform throughout the city.

Electromagnet Pulse $\left(\frac{CAE}{em}\right)$

The electromagnetic pulse from the assumed nuclear blast would not be likely to damage electrical motors and heavy switchgear, particularly in an area such as Albuquerque where electrical storms are common and protection from lightning damage is essential.

Electronics gear in some of the telemetering and remote control installations may experience some damage, but such systems will be largely put out of service in any case by blast and fire damage.

Environmental Effects $\left(\frac{\text{CAE}}{\text{env}}\right)$

No significant effects on natural earth or water characteristics are to be expected at Albuquerque.

V DAMAGE TO PROPERTY $\left(\frac{\text{CPD}}{\text{T}}\right)$

The damage to the Albuquerque water system would include both direct and indirect effects. Damage and destruction of components in the system due to airblast, ground shock, high wind velocities and thermal radiation must, of course, be assessed. In addition, the effects due to structural failures of buildings and fires in the service areas must be considered.

Reservoirs

The reservoirs would be affected by the air blast overpressures and by the resulting ground shock in some cases. They might also be affected by the dynamic pressure, particularly by missile damage, but thermal radiation will not be a significant factor.

At 9:13 p.m. on August 24, 1965, the peak water demand for the day would have been past, and the water levels in the reservoirs would have been recovering from the low point of the day. Engineering Science, Inc. assumed in their study[1] that all reservoirs were five feet below full level at the time of the attack and this same assumption will be used in this analysis. This would mean that there would have been about 92 MG in storage at the time of attack, and that all reservoirs would have had a substantial volume of water, which would have enhanced their structural stability.

Analysis of selected structures by URS Research Company, Burlingame, California, quoted in Ref. 1, indicates that the reservoirs located in areas of less than 3 psi peak overpressure would, in general, be completely usable postattack; those in areas from 3 psi to 7.5 psi would be moderately to severely damaged, depending on the type of construction and pressure involved, and their usability would vary accordingly. Reservoirs in areas of more than 10 psi peak overpressure would be completely unusable postattack.

Analyses of ground shock[8] indicate that the area out to about the limit of 6 psi peak overpressure would experience ground particle accelerations in excess of 10 g, and that the maximum transient particle displacements would be 1 to 2 inches horizontally and about 3 inches

vertically. Differential responses to these motions between the ground and the above-ground mass of the reservoir and its contents would cause stresses far beyond the capability of the reservoir connections and piping fixtures to resist. Therefore it will be assumed in this analysis that any reservoir located in an area where the peak air blast overpressure reached about 6 psi would have been ruptured at the outlet.

Based on the above criteria, the Albuquerque Water System would have had about 92 MG in storage in 30 reservoirs at the time of attack. Nine reservoirs would have been structurally destroyed by the air blast, and seven more would have ruptured outlets due to ground shock, so that the water would be lost immediately.

This would leave about 37.6 MG in storage immediately post-attack, but some leakage would be occurring from a few reservoirs, and house piping and service connections would be ruptured and leaking in many areas.

The details of predicted damage for all reservoirs are given in Appendix C. Post-attack reservoir conditions are given in Table 7.

The conservation of the water in storage immediately postattack and the restoration of service in portions of the system would depend on closing valves to isolate those parts of the system where leakage is occurring due to destruction of major facilities or rupture of service connections and piping caused by blast damage, ground shock, and fires in buildings. This will be discussed in detail under the postattack system capability predictions.

Wells

Damage to wells, as discussed here, refers to damage to surface equipment such as pumps, controls, piping and buildings. In any area where the ground shock magnitude is adequate to cause disruption of the well or casing, the air blast and dynamic overpressure forces have essentially demolished all surface equipment.

Analysis of selected facilities by URS Research Company, Burlingame, California, (as quoted in the ESI report[1]) indicates that small pump and control shelters, with roofs and siding consisting of wood or sheet-metal, and with light wood framing, would lose roofs, windows and doors and would have damage and some loss of walls in overpressure ranges between 2.0 psi and 2.7 psi, but the framing would probably remain unless the overpressure approached the maximum. In this range there would

Table 7

POSTATTACK RESERVOIR CONDITIONS

Reservoir	Construction Type	Peak Over-Pressure (psi)	Postattack Condition
Atrisco #1	Reinforced Concrete	2.6	Good - Possible Debris at outlet
Atrisco #2	Welded Steel	2.7	Good
Burton #1	Reinforced Concrete	7.5	Outlet Ruptured
Burton #2	Reinforced Concrete	7.5	Outlet Ruptured
Candelaria	Welded Steel	3.6	Fair - Slight Leakage
Don	Welded Steel	1.7	Good
Duranes	Prestressed Concrete	2.7	Possible Slight Leakage
Franciscan	Welded Steel	1.7	Good
Glenwood Hills	Prestressed Concrete	6.2	Outlet Ruptured
Griegos	Welded Steel	2.6	Good
Gutierrez	Welded Steel	6.4	Outlet Ruptured
Kiva	Prestressed Concrete	6.3	Outlet Ruptured
Leyendecker	Welded Steel	5.1	Fair - Some Leakage
Linda Vista	Welded Steel	12.5	Destroyed
Lomas #1	"Pritzger" Concrete	13.0	Destroyed
Lomas #2	Prestressed Concrete	13.0	Destroyed
Love #1	Reinforced Concrete	13.3	Destroyed
Love #2	Reinforced Concrete	13.3	Destroyed
Love #3	Reinforced Concrete	13.3	Destroyed
Ponderosa	Welded Steel	6.8	Outlet Ruptured
Ridgecrest	Reinforced Concrete	13.0	Destroyed
Sandia Manor	Bolted Steel	12.8	Destroyed
San Jose	Welded Steel	4.4	Fair - Some Leakage
Simms	Prestressed Concrete	5.5	Possible Roof Debris at Outlet
Supper Rock	Welded Steel	13.0	Destroyed
Thomas	Welded Steel	5.8	Outlet Ruptured
Valley Gardens	Welded Steel	2.3	Good
Vol Andia	Welded Steel	4.3	Fair - Some Leakage
West Mesa	Reinforced Concrete	1.9	Good
Yale	Reinforced Concrete	5.3	Possible Roof Debris at outlet

be some missile damage to wiring and controls, but probably little or no complete loss of equipment. At about 2.7 psi peak overpressure, complete destruction of this type of structure becomes possible, and is probable above 2.7 psi.

Masonry shelters would lose roofs, windows and doors at overpressures above 2 psi, but would not have significant wall damage until overpressures reach 3 to 4 psi and would not be likely to fail completely below about 6 psi. Here again, missile damage to light equipment would be likely in the lower pressure ranges, but complete loss of components within the buildings would not be highly probable until failure of the walls occurred.

Damage to pole mounted conductors would occur at 2.5 to 3.0 psi, or lower if tree limbs were involved, and failure of the poles would occur at 3.5 to 4.0 psi. Pole mounted transformers would probably be blown down at 4.0 psi and above.

Based on the above criteria, it is concluded that of the 68 wells in the Albuquerque Water System, only the two West Mesa wells, where peak overpressure would be about 1.9 psi, would be operable immediately postattack. These two wells could be put back in operation as soon as trouble spots in the power system had been isolated and power in the northwest sector turned back on.

Some wells in the Duranes and Griegos well fields, where peak air blast overpressure would be 2.5 to 2.7 psi, and some in the Valley Gardens system, where overpressure would be 2.2 to 2.4 psi, could be restored to service fairly readily. One well each in the Duranes and Griegos fields and both wells in the Valley Gardens field are housed in masonry shelters and would sustain only minor damage. These could be restored in a few hours to a few days.

Other wells in the Duranes and Griegos fields, and in the Atrisco well fields, where overpressures would range from 2.6 to 2.9 psi, could be restored over a period of weeks. The pump and control houses in these cases are sheetmetal, so there would be more extensive damage to light equipment and complete loss of some items. Restoration would require cannibalization of some units; complete restoration would not be practicable until some new equipment became available.

Some pumping capacity could be restored eventually in the Candelaria and Vol Andia well fields, but this would also require cannibalization. It is not assumed that any use could be made of other well fields in the early postattack months, except for recovery of some equipment useful in the above-mentioned restorations.

A detailed discussion of postattack well production capabilities will be presented under postattack system capability predictions. Damage predictions are given in Appendix C.

Booster Pumping Stations

The twenty-seven booster pumping plants in the Albuquerque water system are all in buildings. Six are in sheetmetal buildings with wood framing, four in concrete buildings and seventeen in relatively new masonry buildings.

Windows and doors would be blown in at every location in the system and some damage by missiles to controls, wiring and other light equipment would result. Roofs would be torn off where peak airblast overpressures exceeded about 2.1 or 2.2 psi, increasing the probability of missile damage.

Siding would be torn off of sheet metal buildings above about 2.4 psi, and some failure of the framing would occur above about 2.7 psi. Thus, damage to controls, wiring and other light equipment would become increasingly severe above 2.4 psi and complete loss of some components would be expected above 2.7 psi.

Of the four pumping plants housed in concrete structures, Atrisco #1 and Candelaria are one-story structures and would not incur serious damage to the walls. The San Jose plant is in a two-story structure, but wall damage would not be serious at the 4.0 psi overpressure predicted. The Main Plant facility is in a very old building and the height is about equivalent to two-stories. Some structural failure of the walls would occur and the damage to controls and other light equipment would be extensive.

Air blast and wind damage to the walls of the newer masonry structures would not be serious below about 6 psi, but some structural failure would occur above 6 psi, and destruction of all but the heaviest equipment within these buildings would occur at 10 psi or above. The missile damage due to roof, window and door failures would become increasingly severe as the point of wall failure was approached.

Of the twenty-seven booster pumping plants, two would sustain only very light damage and could be put back in service as soon as the electrical power was restored. These stations are the West Mesa and Don plants.

The stations at Duranes, Griegos and Valley Gardens would sustain only moderate damage and could be put back in service within a few days. Facilities at Candelaria and Vol Andia would experience extensive damage to light equipment, but could be put into partial services within a few weeks, cannibalizing other units where necessary.

All of the remaining plants would be so seriously damaged that emergency repairs would not be practical, especially considering the conditions of other system components in the areas involved.

A detailed discussion of the post attack conditions of the pumping plants will be given under postattack system capability predictions. The predicted damage to all components is given in Appendix C.

Pipelines

No damage to pipelines would be expected except where exposed at the surface or attached to some structure that would respond differently to ground shock. Most major pipeline exposures in Albuquerque occur in areas where the system would be completely unusable due to other factors.

The major pipelines attached to bridges across the Rio Grande and across the freeway west of the Rio Grande would not incur any significant damage.

Failure of the connections between major pipelines and reservoirs has been discussed in a previous section, and the problem of connections to buildings and piping within buildings will be discussed under Services.

Fire Hydrants and Valves

The fire hydrants in Albuquerque are almost entirely of the dry barrel type, so that breakage at the surface would not open the pipelines. Any significant breaching of the water mains due to breakage of fire hydrants or street valves would only occur in the areas of very high ground shock. Within this zone, the surface destruction would be so complete that what happens underground would be immaterial.

Similarly, the damage to major valves at pumping plants and reservoirs would be immaterial, because at the airblast overpressures where this would occur, the destruction of the related surface facilities would be essentially complete.

Services

This discussion of damage to services includes any damage to piping or fittings that would cause uncontrolled flow of water beyond the corporation stops at service connections. The damage might be to meters or meter fittings, to service connections to the buildings or to piping and fittings within the buildings. The damage might be caused by differential motion between the piping and the buildings due to ground shock, by structural damage to the buildings caused by air blast, or by fires within the buildings due to the thermal radiation or to other causes subsequent to the attack.

Rupture of one service connection would not have a significant effect on the water system capability, but in areas where widespread structural damage or fires would result in leakage at substantial percentages of the total services, this factor must be considered in predicting the post-attack capability of the system.

Building-by-building analysis of these effects is impossible; the predictions must be made on the basis of the probabilities of leakage, considering the predicted air blast pressures, magnitude of ground shock, the incidence and duration of fires and the densities of service connections in the various zones.

Density of Services

Exact data on the total numbers of services in Albuquerque or the distribution throughout the area are not available. However, an estimate prepared by the Water Division indicates there were about 62,140 services as of August, 1965. As noted in the target model description under "Area Population and Housing," there were an estimated 78,710 housing units in the City at that time, and if the number of services can be assumed to be proportional to the housing units in each census tract within the area, the approximate densities can be computed for the various census tracts. With the further assumption that the housing units are distributed uniformly within each census tract, an approximation of the number of services within each water service pressure zone, and within several ranges of peak blast overpressures, can be made. Table 8 shows this distribution.

It will be noted that about 87 percent of the water service connections are in areas that would be exposed to 3 psi or more peak overpressure, and 25 percent would be exposed to 10 psi or more.

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Table 8

DISTRIBUTION OF WATER SERVICE CONNECTIONS IN ALBUQUERQUE

Pressure Zone	Peak Air Blast Overpressure 10 psi	5 to 10 psi	3 to 5 psi	3 psi	Total	Percentage
3 W						Negligible
2 W				1,360	1,360	2.2%
1 W				870	870	1.4%
0 W				50	50	0.1%
1 E		210	13,940	5,670	19,820	31.9%
2 E		8,360	2,070		10,430	16.8%
3 E	8,260	11,040	120		19,420	31.2%
4E & 5E	5,270	1,880			7,150	11.5%
6 E	1,200	500			1,700	2.7%
7 E	740	330			1,070	1.7%
8 E	105	165			270	0.4%
9E & 10E						Negligible
11E & 12E						Negligible
Totals	15,575	22,485	16,130	7,950	62,140	
	25.0%	36.2%	25.9%	12.8%	100%	100%

Leakage at Services

Destruction of buildings by air blast would be essentially complete in all areas where the peak overpressure was 5 psi or more.[10] Between 3 psi and 5 psi there would be nearly complete loss of windows and extensive damage to doors and roofs, as well as considerable damage to walls and framing. Probably 50 percent of the houses would be wracked to the extent that piping or water fixtures would be ruptured, and a substantial number would fail completely. In the balance of the City, which would experience 2 psi to 3 psi, window and roof damage would be extensive, but structural failure would be relatively unusual.

Predictions made by IIT Research Institute[9] indicate that, within the total Albuquerque area, 25.6 percent of the buildings would be severely damaged by blast and 57.0 percent would be destroyed by fire within 28 hours after the burst. This study considered a larger area than that served by the Albuquerque Water System, so this prediction would correspond to a prediction of 85 to 90 percent destruction, either by blast or subsequent fires within the water service area. The IITRI prediction of destruction by air blast and fire is shown on Figure 10, along with the peak overpressure prediction. Uncontrolled water flow would occur at most of the destroyed buildings whether the damage was caused by air blast or fire.

On the above basis it is estimated that water losses would occur at services as indicated in Table 9. Obviously large areas would have to be entirely isolated and many services would have to be shut off in the remaining areas in order to maintain or restore any water supply capability in the postattack period.

Water Treatment

Water treatment in Albuquerque involves only chlorination, done automatically at the inlets to the primary reservoirs. These facilities could probably be rehabilitated at the remaining usable reservoirs as fast as wells could be put back in operation. In any places where this could not be done, provision for manually controlled addition of chlorine to the reservoirs could be readily made.

The supplies of chlorine kept on hand for normal operation would last for an extended period with the reduced postattack water production, and the majority of these supplies could probably be salvaged.

Table 9

PREDICTED POSTATTACK LEAKAGE AT SERVICES
August 1965

(A) By Peak Air Blast Overpressure Limits

Peak Over-Pressure (psi)	Total Services	Percentage Leaking	Number Leaking	Water Loss Rates Per Service* (gpm)	Total (gpm)	Total (mgd)+
5 or more	38,060	Nearly 100%	38,000	2.0	76,000	109.5
3 to 5	16,130	90%	14,500	1.0	14,500	20.9
2 to 3	7,950	20%	1,600	0.5	800	1.2
Totals	62,140	87%	54,100	--	91,300	131.6

(B) By Water Service Pressure Zones

Pressure Zone	Total Services	Number Leaking	Leakage* Per Service (gpm)	Total Loss Rate (gpm)	Total Loss Rate (mgd)
2 W	1,360	270	0.5	135	0.2
1 W	870	180	0.5	90	0.1
0 W	50	10	0.5	5	--
1 E	210	209	2.0	418	0.6
	13,940	12,534	1.0	12,534	18.1
	5,670	1,140	0.5	570	0.8
Zone Total	19,820	13,883		13,522	19.5
2E	8,360	8,350	2.0	16,700	24.0
	2,070	1,858	1.0	1,858	2.7
Zone Total	10,430	10,208		18,558	26.7
3 E	19,300	19,270	2.0	38,540	55.5
	120	108	1.0	108	0.2
Zone Total	19,420	19,378		38,648	55.7
4E & 5E	7,150	7,140	2.0	14,280	20.6
6 E	1,700	1,695	2.0	3,390	4.9
7 E	1,070	1,067	2.0	2,134	3.1
8 E	270	269	2.0	538	0.8
Total	62,140	54,100		91,300	131.6

* Involves a very rough scaling to probable degree of damage. Approximate flows per service in Albuquerque are as follows: Annual average, 0.5 gallons per minute (gpm); peak day, 1.0 gpm; peak hour 2.0 gpm.

\+ Million gallons per day.

VI DAMAGE TO PEOPLE $\left(\frac{CHD}{T}\right)$

The Albuquerque Water Division had 132 employees in August of 1965, but 49 of these were in commercial and support activities that are not essential to emergency operation of the system.

The Division is divided into three sections: Engineering, Maintenance and Construction, and Operations. The personnel considered critical to postattack operations totaled 17, 47 and 19 respectively in these sections.

An analysis of the probable deaths and injuries to this group has been made, assuming that, just prior to the attack, they were at their residences unless on duty, and that their movements to shelters were typical of the population as a whole. It was assumed that none of these people left the City prior to the attack.

The population locations prior to the attack, movements to shelter, and estimates of casualties were taken from the Dikewood reports for Albuquerque.[4,12,14]

The Dikewood reports estimate total populations in 42 standard location areas (SLAs)[4] in Albuquerque at the time of the attack, and estimate total deaths and injuries resulting from the attack in the same SLAs.[12,14] From these figures, factors for the probability of death and of injury can be derived for individuals located in each of the SLAs.

Water Division management indicated that one Plant Operator and three Trouble Spotters would have been on duty at the Central Control Station at the time of the attack, but the records as to who had this duty the evening of August 24, 1965 were not available. Therefore, one Operator out of the four on the staff and three Trouble Spotters out of the twelve on the staff were selected by a random number process. These four men were assumed to be located at the Central Control Station at the time of attack.

All other personnel were assumed to be at their residences prior to the attack, and were assumed to move to shelters in accordance with the Dikewood Supplement.[14] Each person was assumed to run the average risks of death and injury for the SLA in which he was located at the time of attack. The risk factors for the various SLAs were expressed in terms of deaths or injuries per 1,000 total population in the SLA.

Each individual in turn was assigned a block of numbers in the range of 000 through 999 proportional to the risk factor for the SLA. A column and line number from a table of random numbers was then assigned arbitrarily, and if the indicated number fell within the block assigned to the individual, he was assumed to be a casualty. This process was used first to determine the deaths, then repeated for the survivors to determine the injuries.

The random number table that was used[15] consists of 14 columns with 50 lines each. The last three digits of each number were used to give a range from zero through 999.

The results of the analysis showed 9 killed, 26 injured and 48 unaffected out of the 83 critical employees. Table 10 shows the results by Division sections and by job classifications.

Table 10

WATER DIVISION CASUALTIES
CRITICAL PERSONNEL
August, 1965

	Total Number	On Duty	Killed	Injured	OK
Engineering					
Chief Water Engineer	1				1
Asst. Ch. Water Engineer	1				1
Electrical Engineer	1				1
Civil Engineer	1				1
Inspectors	3			2	1
Survey Crew	4			2	2
Engineering Technician	1				1
Engineering Draftsmen	4			2	2
Information & Drawing Clerk	1				1
Subtotal	17	0	0	6	11
Maintenance and Construction					
Super. Maint. & Construction	1				1
Genl. Foreman	1			1	
Information Clerk	1				1
Construction Foreman	2			2	
Leak detectors	2				2
Pipefitters	2				2
Pipefitters helper	1				1
Laborers	6		1	1	4
Pipe Maintenance man	4		1	2	1
Pipe Maintenance helper	7		1	3	3
Tamping Pipefitter	1			1	
Tamping Pipefitter helper	1				1
Tamping laborer	2			1	1
Backfill laborer	4			3	1
Backfill Truck Driver	3				3
Backfill Operator	1			1	
Electrician	1		1		
Electro-technician	1		1		
Instrument Repairman	2				2
Machinist	1				1
Pump Technician	1			1	
Corrosion Technician	1				1
Corrosion Laborer	1				1
Subtotal	47	0	5	16	26
Operations					
Supt. of Operations	1				1
Water Superintendent	1				1
Operator	1				1
Plant Operators 2 & 3	16	4	4	4	8
Subtotal	19	4	4	4	11
Grand Total	83	4	9	26	48

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VII DAMAGE TO SYSTEMS $\left(\frac{CSD}{i}\right)$

Supplies and Equipment

Most supplies and equipment for the Albuquerque Water System are normally kept at the City Yard, which would be subjected to nearly 4 psi peak air blast overpressure. However, Water Division management has indicated that, given the warning sequence assumed for this attack,[5] many of the vehicles would have been dispersed in charge of off-duty personnel, and that special precautions would have been taken to assure that each vehicle was well equipped with tools and supplies.

The management would have planned to distribute the vehicles as nearly as possible around the periphery of the City, so that there would be a maximum chance for at least some of them to be usable postattack. The plan has not been worked out in the detail that would allow prediction of exact locations for specific vehicles, but it so happens that the majority of the construction and operations field personnel live in the westerly part of the city.

It can be assumed that most of the work vehicles would have been in the areas of lesser air blast pressures, so that a substantial proportion would have been operable postattack. Of the 42 trucks and pickups assigned to the Water Division it is probable that about 20 would have been usable postattack. In addition, two of the nine sedans would have been operable.

Power Supply

Aside from water retained in reservoirs, which might be delivered to limited areas by gravity, the postattack capability of the Albuquerque Water System depends on power for the wells and booster pumps. All of the wells and most of the boosters depend on electric power. A few booster pumps are equipped with auxiliary engines using natural gas for fuel.

Electricity

Albuquerque is completely circled with 115 kv transmission lines which link the three local generating stations and tie to the Santa Fe

system to the north. In addition, there are 46 kv lines linking with Santa Fe and with Belen, to the south.

The major transmission facilities around the east and south sides of the city would either be destroyed or damaged beyond the possibility of emergency repair. However, those to the north and west would receive little or no damage.

Of the three local generating plants, Persons Station (114,000 kva) would be subjected to the highest air blast overpressure, between 4 psi and 5 psi peak. This would cause moderate to heavy damage to the station itself, as well as extensive damage to transmission lines. Prager station (31,400 kva) would experience about 2.9 psi peak overpressure, indicating light damage at the station, but the transmission lines would probably sustain little or no damage. Reeves station (174,000 kva) would also experience about 2.9 psi, but it is remote from other structures and from any large trees. This station would probably suffer very little damage, and the transmission lines should not be damaged at all.

All electrical service in Albuquerque would undoubtedly be out immediately postattack due to damage and short circuits in the distribution system, but it would be possible to restore some service in the west and northwest portions of the city in a relatively short period, using power from Reeves Station and/or the tie line to Santa Fe, and transmission facilities into the city from the west and north. The seriously damaged portions of the system would have to be isolated and some damage to distribution lines from missiles and trees would have to be repaired.

Natural Gas

Natural gas supplies would be completely disrupted immediately postattack due to destruction of major facilities and rupture of service connections and other piping at buildings. It is expected that electrical power to still-operable pumping facilities could be restored more readily than either natural gas or substitute bottled gas could be provided.

Communications and Controls

The Central Control Building--nerve center for all radio communications, telemetering of system operations, and remote control of pumps and valves--would be subjected to between 7 and 8 psi peak air blast overpressure, plus ground shock involving particle accelerations of 13 to 14 g.

Destruction of the facility would be virtually complete, and none of the communication and control facilities would be usable postattack.

Mobile vehicle radios are dependent on the Central Control facilities for relay and amplification, so this equipment would not be operable postattack. The telephone utilities would also be so completely disrupted as to be inoperable.

Operations

All telemetering facilities and normal communications facilities would be inoperative postattack. Water system personnel would be widely scattered and some would be without usable vehicles. Vehicle movement through the streets would be difficult because of debris and fires.

Organization and direction of emergency measures would be virtually impossible in the first few hours after the attack, and outdoor movement would have to be restricted after radioactive fallout arrived at D + 13 hours. However, many of the steps necessary to isolate major leaks and begin conservation of the water remaining in storage would be obvious to water system personnel at various locations, and organization of the effort could be achieved after the emergency civil defense communications facilities were put in operation and the message load had decreased somewhat.

Although some of the special skills in the Water Division would have been badly affected by casualties, the engineering and supervisory personnel would have survived relatively well. The unaffected personnel would be adequate for the required work, especially if additional, inexperienced people could be recruited to work with the crews.

VIII DAMAGED SYSTEM CAPABILITY

A discussion of postattack water system capability must be related to the damaged condition of the City and the consequent changes in water requirements. It must also consider the ability of personnel to make adjustments to the system and to make minor repairs, and the availability of equipment, tools and supplies for emergency operations. Although this study is not intended to cover postattack recovery, some reasonable time lapse and level of emergency adjustments and repair effort must be considered in order to make the discussion meaningful. The system capability would be essentially nil if nothing could be done.

Essentially all operation of the system would have to be done manually. All of the remote control facilities and most of the automatic control devices would be inoperative due to damage during the attack.

Postattack Water Requirements

Domestic water requirements would be drastically curtailed during the postattack period, even in areas of minimum damage to buildings. Yard watering and automobile washing, which account for a large portion of normal domestic use, would be eliminated, and bathing and laundry uses would be greatly reduced.

On the other hand, requirements for fire fighting and for decontamination might be greatly increased, and leakage through damaged system components would be a major factor until the damage could be isolated.

Domestic Requirements

The Dikewood casualty study[12] concluded that, out of a total population of about 300,000 in the Albuquerque area, about 40,000 would be killed, and of the 260,000 survivors, about 118,000 would be injured.

As discussed under Weapon Characteristics,[12] fallout would occur over the area starting about 13 hours after the attack, so that population movement would be restricted during most of the first week. In addition, 85 to 90 percent of the housing in Albuquerque would be destroyed either by air blast or by fire, and significant damage would be inflicted on many surviving buildings.

It must be assumed that most of the surviving population would remain in shelters during the first week postattack and that the vast majority would remain at mass care centers until a substantial reconstruction program could be completed. Hospital facilities would be very limited, so that most of the care of the injured would consist of special attention in the shelters and at the mass care centers after they were activated.

The Office of Civil Defense has developed some standards of water requirements for surviving populations,[16] and Table 11 shows the estimated postattack domestic water requirements for Albuquerque, based on these standards and the predicted local conditions.

The requirements are nearly negligible for the first few days and would probably be met largely by water supplies on hand in the shelters. As people moved from the shelters to homes and mass care centers the requirement would increase, but should not exceed 0.75 million gallons per day (mgd) during the second week, nor 6 mgd during the first six weeks. This latter is about six percent of the preattack production capacity.

Fire Fighting

Fire fighting needs would be most urgent during the first 24 hours following the attack; any capability developed after this time would be too late.

Normal minimum fire requirements for a city the size of Albuquerque would be the capability to sustain a flow of about 15,000 gpm for at least 10 hours, or about 22 million gallons available for immediate delivery to the points of need at suitable pressures. Under the emergency conditions that would pertain in Albuquerque after a nuclear attack, the requirements could amount to several times this amount, providing it could be delivered to the critical areas and that men and equipment were available to use it.

Table 11

POSTATTACK DOMESTIC REQUIREMENTS*
August 1965

	Daily Domestic Water Requirements										
	Homes and Shelters			Hospitals			Mass Care Centers			Total	
Postattack Period	GPCD	P	MGD	GPCD	P	MGD	GPCD	P	MGD	Incremental MGD	Accumulative MG
Survival Period (D-Day to D+7 days)	0.5	260,000	0.13	5.0	0	-	3.0	0	--	0.13	0.91
Early Recovery Period (D+8 to D+14)	0.5 to 5.0 use 2.5	255,000	0.64	15	5,000	0.08	10	0	--	0.72	5.04
Restoration Period (D+15 to D+40)	5.0 to 40 use 30	35,000	1.05	25 to 40 use 40	5,000	0.20	15 to 25 use 20	220,000	4.40	5.65	141.25
Reconstruction Period (After D+40)	40 40	55,000	2.20	40	5,000	0.20	25	200,000	5.00	7.40	--

GPCD = Gallons per capita per day
P = Population
MGD = Millions of gallons per day
MG = Millions of gallons

* Source: Ref. 16, per capita water requirements.

The analysis of damage to the water system indicates that well production and booster capacity would be nil immediately postattack, and that the water in storage would total less than 40 million gallons. In addition the system would have substantial leakage at damaged reservoirs and at services. Due to the widespread leakage, most of the mains would have to be closed off during the critical fire period while damaged services and other trouble spots were being isolated.

It is concluded that no substantial amount of firefighting would be possible using supplies from the Albuquerque water system.

Decontamination

Neither water, equipment, nor manpower would be available for decontamination in the Albuquerque area during the first week. The radioactive fallout would decay to levels less than one roentgen per hour within this week[15] and very little in the way of decontamination could be accomplished during this period in any case. No water will be used for decontamination.

Reservoir Storage

The analysis of system damage indicates that there would be about 37.6 million gallons (MG) of water in storage at the time of the attack, not counting reservoirs that would be destroyed or seriously damaged. Simms reservoir, with 2.22 MG is located in Zones 9E and 10E, and the system leakage below this elevation would be adequate to drain it in a very short time. However, the piping from the reservoir is only 12-inch diameter, and debris from the reservoir roof would probably restrict the outflow somewhat. It is estimated that 1.0 MG of this storage could be conserved, for use after the system damage had been isolated.

Don (3.46 MG) and Franciscan (1.31 MG) reservoirs are located in Zones 2W and 3W respectively. Here again the potential leakage is adequate to drain the reservoirs very rapidly, but the relatively small pipeline sizes (12-inch) will slow the losses somewhat. It is concluded that 2.5 MG of this storage could be conserved.

Leyendecker reservoir (5.12 MG) is located in Zone 2E. The high potential loss rate and large pipeline sizes from this reservoir indicate that all of this water would be lost.

Vol Andia (5.07 MG) and Yale (5.87 MG) reservoirs are in Zone 1E. The leakage below this level would still be substantial and both reservoirs have large outlet piping. It is concluded that not more than 1.0 MG could be conserved in Vol Andia Reservoir and that Yale Reservoir would empty, due to difficulty of access to close the outlets.

West Mesa Reservoir (2.91 MG) in Zone 1W is across the river from the areas of highest potential loss rate. Although the reservoir connects to large pipelines, the distance from the major loss areas and restrictions in flow rate at the river crossings would help to save water. It is concluded that 2.0 MG could be conserved in this reservoir.

Six remaining usable reservoirs are all in the primary zones and the leakage potential is very small. Of the 11.27 MG in storage at the time of attack, at least 10.5 MG should be conserved. Valley Gardens Reservoir, which serves a small isolated area, is assumed to contain 4.22 MG at the time of attack; at least 4.0 MG of this should be conserved.

The total stored water available after initial emergency steps to isolate leakage had been completed would be about 17 MG. Essentially no distribution of water would be possible until leaking service connections had been closed and pressure could be restored in the mains, and then only about 3 to 4 MG could be delivered previous to restoration of some booster pump capacity. Table 12 shows the postattack conditions for the remaining usable reservoirs.

There would be no significant supplies for fire fighting or decontamination, but there would be an adequate supply for population survival needs. Means for hauling water to many areas would be required for a while, because the distribution system would be inoperative.

There would be about 38 MG of usable reservoir capacity in the system, once the leaks had been isolated.

Well Capacity

Peak air blast overpressure would be less than 2 psi at the West Mesa wells. The equipment there is housed in masonry buildings, so there would be only light damage from failure of windows and possibly doors. The damage could be repaired and the wells could be operable as soon as power was available.

Table 12

PREDICTED POSTATTACK RESERVOIR CAPABILITY
August 1965
(Quantities in Millions of Gallons)

Reservoir	Pre-Attack Capacity	In Storage at Attack	Remaining After Leakage	Eventual Usable Capacity
Zones 9E & 10E				
Simms	2.52	2.22	1.0	2.22
Zones 3W & 3E				
Franciscan	1.53	1.31	0.5	1.53
Zones 2W & 2E				
Don	4.03	3.46	2.0	4.03
Leyendecker	6.00	5.12	0	5.00
Subtotal	10.03	8.58	2.0	9.03
Zones 1W & 1E				
Vol Andia	6.00	5.07	1.0	4.00
West Mesa	4.00	2.91	2.0	4.00
Yale	8.06	5.87	0	8.06
Subtotal	18.06	13.85	3.0	16.06
Primary Zones				
Atrisco #1	0.08	0.04	0	0.0
Atrisco #2	3.00	2.53	2.5	0.0
Candelaria	0.62	0.49	0.3	0.0
Duranes	4.29	3.52	3.5	4.29
Griegos	3.00	2.53	2.5	3.00
San Jose	2.50	2.16	1.7	2.00
Subtotal	13.49	11.27	10.5	9.29
General System Total	45.63	37.23	17.0	38.13
Separate System				
Valley Gardens	0.50	0.42	0.4	0.50
Grand Total	46.13	37.65	17.4	38.63

Peak overpressures would be less than 2.5 psi at the Valley Gardens wells, 2.5 to 2.7 psi at the Duranes and Griegos wells, and 2.6 to 2.9 psi at the Atrisco wells. Both pump houses at Valley Gardens are masonry, as are one each at Duranes and Griegos. The rest of the pump houses are sheetmetal, except for one wooden shelter at Atrisco No. 2

The equipment in the above well fields housed in masonry buildings would receive only light damage to wiring and controls, and could be readily repaired. The units in sheetmetal and wood buildings would receive moderate to heavy damage to wiring and controls, but no significant damage to heavy equipment. Many of these units could be rehabilitated either by repairs or by cannibalization of other plants.

The Vol Andia wells would be subjected to between 4 and 5 psi and there would be substantial damage to all light equipment, but there would be no complete structural failures of the masonry shelters. Because of the strategic location of the wells, the high production rates, and the likelihood of power availability, it has been assumed that some wells in the Vol Andia field would be rehabilitated fairly soon in the postattack period. This would undoubtedly require salvaging some light equipment from other plants.

The possible capabilities for well production in the postattack period are shown in Table 13. This analysis shows that the production could be adequate for the foreseeable requirements, once the distribution mains were put back in service.

Booster Pumping Capacity

Damage estimates for the 27 booster pumping plants of the Albuquerque Water System indicate that four would be essentially destroyed, with only portions of the heavy equipment salvagable, and nine would have the lighter equipment destroyed, but much of the heavy equipment usable or repairable. Three stations would have heavy damage to the lighter equipment, but only moderate damage to the heavy equipment. Some of the light equipment at these plants could be salvaged and repaired for use at other locations.

The remaining eleven stations would sustain only light to moderate damage, mostly due to missiles from windows, doors and roofs of the shelters. These plants could be repaired with materials on hand or using salvage from other stations.

Table 13

POSTATTACK WELL PRODUCTION CAPACITY
August, 1965

	Water Pressure Zone	Pre-Attack Number of Wells	Pre-Attack Capacity (gpm)	Postattack Capability (gpm) D-Day to D+7	D+8 to D+14	D+15 to D+40	After D+40
Atrisco #1	1W	3	3,400	0	0	1,000	3,400
Atrisco #2	OW	8	4,550	0	0	1,000	4,550
Duranes	1E	7	12,900	0	2,100	7,000	10,000
Griegos	1E	5	9,870	0	2,000	4,000	9,870
Vol Andia	2E	6	18,100	0	0	3,000	9,000
West Mesa	2W	2	2,250	--	2,250	2,250	2,250
Subtotal		31	51,070	0	6,350	18,250	39,070
Valley Gardens	Separate	2	750	0	600	750	750
Total		33	51,820	0	6,950	19,000	39,820
Total (mgd)			74.6	0	9.1	27.4	57.4

Table 14 shows eight stations that could be put back in service within a reasonable period after the attack. The time allowed for restoration is roughly a measure of the degree of damage. However, in some instances the choice of which station or unit to restore has been influenced by the strategic location in the system rather than the relative damage. In some plants, it has been assumed that some units have been cannibalized in order to restore other units.

The analysis shows that ample booster pump capacity to meet the postattack needs could be restored as quickly as the distribution system could be put back in operation.

Controls and Treatment

All of the remote monitoring and control facilities and most of the automatic and semi-automatic devices would be inoperable in the postattack period. However, all remote-controlled and automatic facilities can also be operated manually. The entire system, including the chlorinators, would have to be operated manually.

Supplies and Equipment

As stated previously, the Water Division mangement would have dispersed the vehicles in charge of various employees to the periphery of the City, and would have had a full complement of tools and supplies in each work vehicle. An analysis of residence locations for Division personnel indicated that 2 out of 9 sedans and 20 out of 42 work vehicles would probably be operable after the attack. This would be enough vehicles to serve the essential functions under emergency conditions.

Personnel Capability

The previous analysis of Water Division personnel casualties showed that, out of 83 critical employees, 9 would have been killed and 26 would have been injured, a loss of 42 percent. The casualties did not include the top individuals in any of the three sections, but did include the general foreman and both construction foremen in the Maintenance and Construction section.

Table 14

POSTATTACK BOOSTER PUMPING CAPACITY
August, 1965

		Pre-attack		Postattack Capacity (gpm)			
	Water Pressure Zones	Number of Pumps	Total Rated Capacity (gpm)	D-Day to D+7	D+8 to D+14	D+15 to D+40	After D+40
Atrisco #1	Prim. to 1W	2	3,900	0	0	1,400	3,900
Atrisco #2	Prim. to 1E	4	4,000	0	0	2,000	4,000
Don	2W to 3W	2	800	0	800	800	800
Duranes	Prim. to 1E	4	15,600	0	2,800	7,800	10,600
Griegos	Prim. to 1E	3	13,400	0	3,400	8,400	13,400
Vol Andia	1E to 2E	4	17,000	0	0	4,000	12,500
West Mesa	1W to 2W	4	3,800	0	2,400	3,800	3,800
Subtotal		23	58,500	0	9,400	28,200	49,000
Valley Gardens	Separate	4	970	0	800	970	970
Total (gpm)		27	59,470	0	10,200	29,170	49,970
Total (mgd)			85.7	0	14.7	42.0	72.0

The Engineering section would have lost 2 out of 3 inspectors, 2 out of 4 survey crew members and 2 out of 4 engineering draftsmen.

The Maintenance and Construction section would be the hardest hit, with nearly 45 percent casualties, including all of the foremen and both electricians.

The Operations section would have about 42 percent loss, but this involves 8 plant operators out of a total of 16, so that no unique capability should be lost.

The loss of personnel could be largely offset by recruiting inexperienced help to work with the surviving employees.

The surviving supervisory personnel would be adequate for postattack operations, but coordination of the total effort would be seriously hampered by lack of communications until emergency radio facilities could be put into operation.

Supporting Utilities

No general analysis of the postattack communication utility capability has been included in this study, but it is assumed that the civil defense organization would be able to activate emergency broadcasting facilities within a short time after the attack, and that these facilities would be the major means of communication in the postattack period.

Electric power would be completely off immediately postattack, but some power could be restored in the northwest portion of the City after some minor repairs and isolation of this area from the rest of the system. An allowance for some time delay in restoring electric power has been included in the analysis of postattack water system capability.

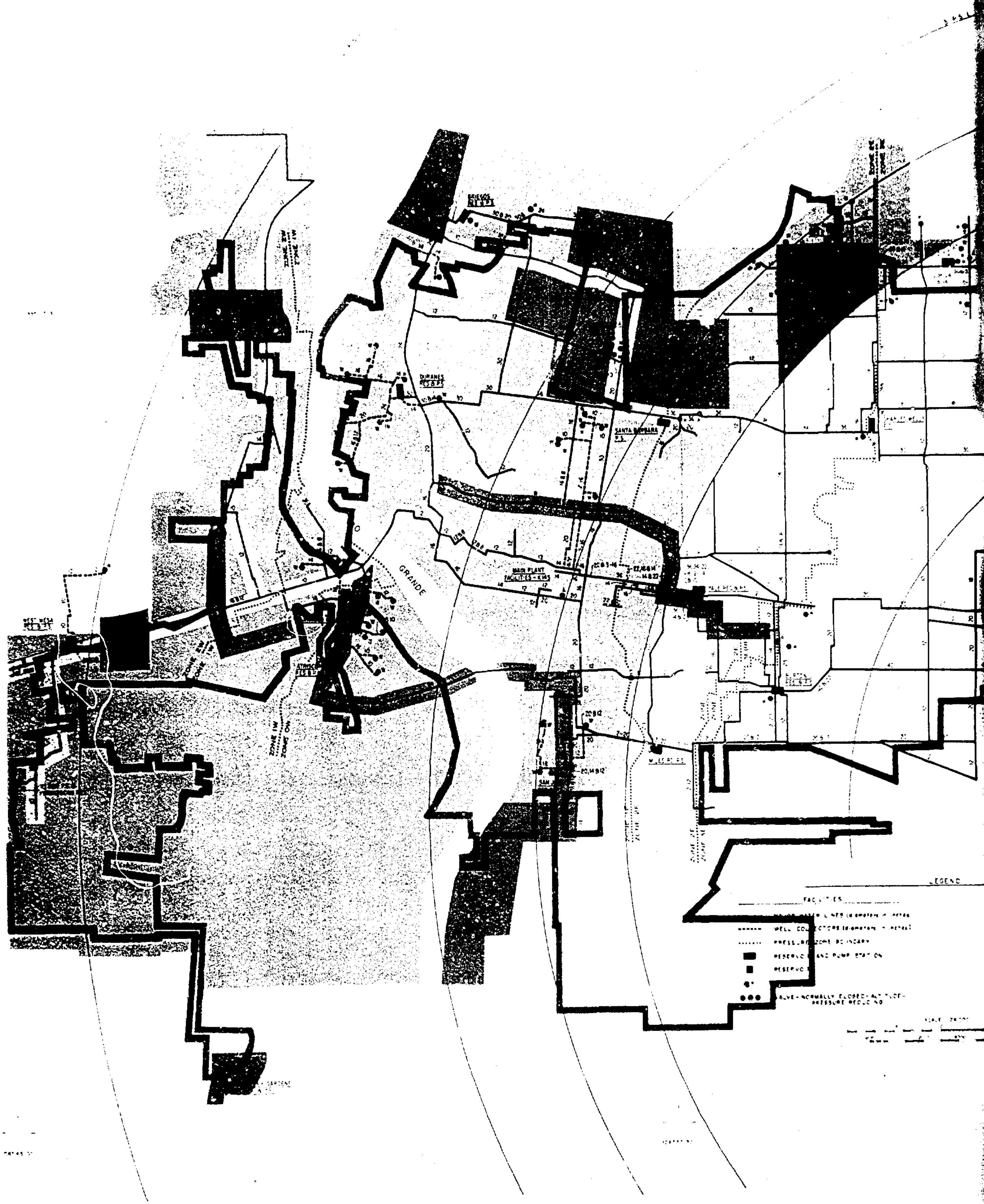
Overall Water System Capability

There would be little or no capability for delivery of water through the Albuquerque distribution system in the immediate postattack period. Even in areas where no ruptures of reservoirs or reservoir piping occurred there would be extensive leakage at service connections and in building piping, and there would be no power for either well pumps or booster pumps.

There would be a substantial volume of water remaining in reservoirs, but this water could only be conserved if essentially all of the mains were closed in the early postattack period. Water could first be made available along a few of the mains leading directly from reservoirs, after the valves to all laterals had been closed. This would be by gravity flow only, as no power would be available for pumping.

After about a week, with power available to some wells and pumping plants in the western part of the City and with damaged services and house piping isolated, pressure could be restored in most of the major pipelines and in a few small service areas. Service could eventually be restored to most of the remaining buildings in the western part of the City, but it is estimated that this would require six to eight weeks. Figure 11 shows the predicted system capability for three stages in the postattack period.

There would be adequate water supplies to meet the critical domestic requirements at all times during the postattack period, but most of the water would have to be hauled until the surviving population could be moved to areas where distribution was possible. There would be essentially no water available for fire fighting or decontamination during the critical postattack period.



GRANDE
DURANES
SANTA BARBARA
MAIN PLANT
LEGEND
FACILITIES

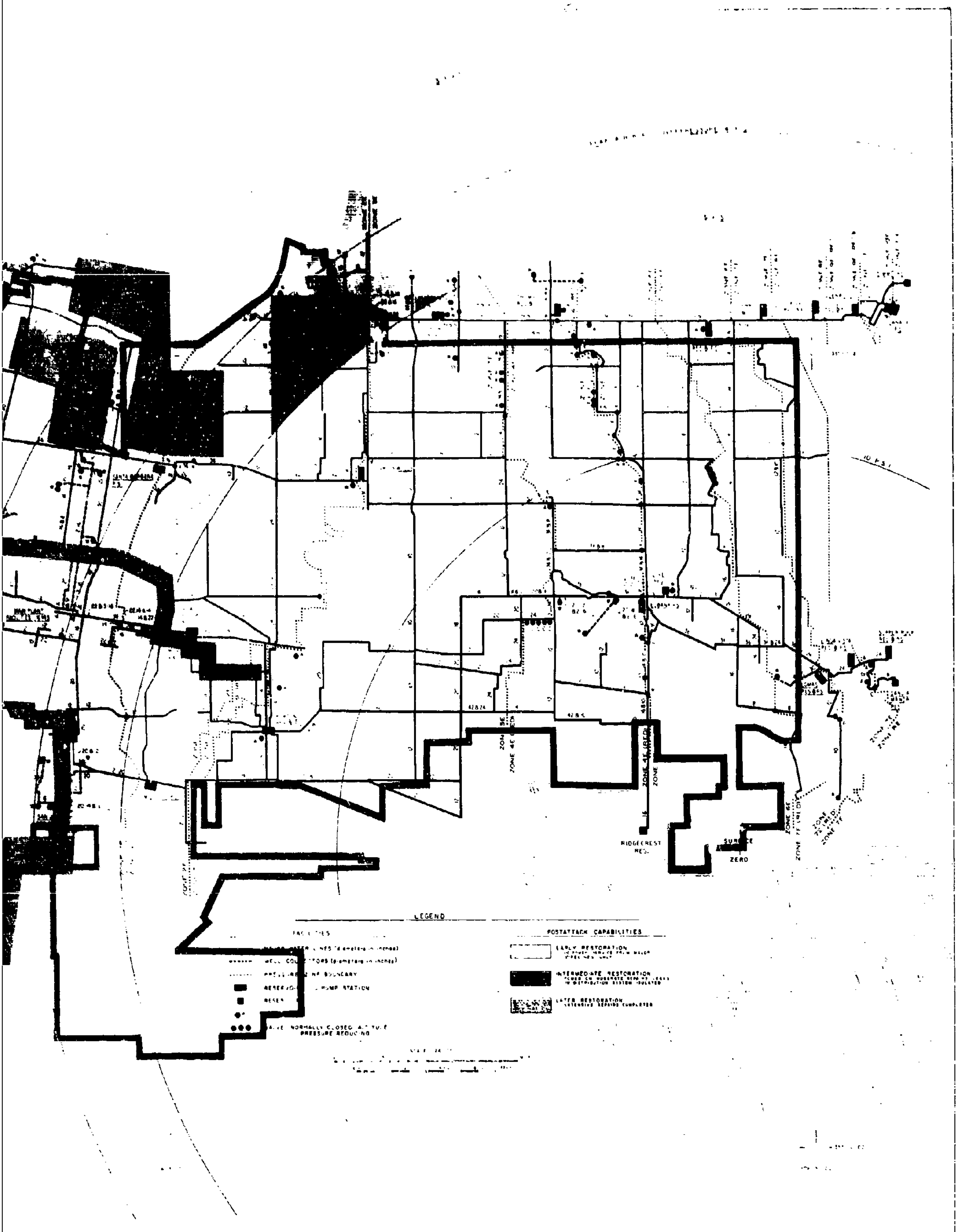


FIGURE 11 POSTATTACK WATER SYSTEM CAPABILITY

Appendix A

ALBUQUERQUE WATERWORKS
INVENTORY OF PUMPING EQUIPMENT
(Wells and Booster Stations)

Appendix A

ALBUQUERQUE WATERWORKS
INVENTORY OF PUMPING EQUIPMENT
(Wells and Booster Stations)

Facility Name	Item No.*	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Volt-age	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Atrisco 1	1	1	Horiz.	Peerless	A/L-G.E.	G.E.	4160	300	350	2500
Boosters		2	Horiz.	DeLaval	R/V-G.E.	E.M.	2300	125	250	1400
Atrisco 1	2	1	Turb.	Layne & Bowler	A/L-C.H.	U.S.	440	60	150	1000
Wells	3	9	Turb.	Peerless	R/V-G.E.	G.E.	440	40	99	1200
	4	13	Turb.	Peerless	R/V-A.C.	U.S.	440	100	200	1500
Atrisco 2	6	1	Horiz.	Peerless	R/V-G.E.	G.E.	4160	300	475	2000
Boosters		2	Horiz.	Peerless	R/V-G.E.	G.E.	4160	300	475	2000
		3	Horiz.	Economy	R/V-Ideal	Ideal	4160	300	475	2000
		4	Horiz.	Economy	R/V-Ideal	Ideal	4160	300	475	2000
Atrisco 2	7	2	Turb.	Layne & Bowler	A/L-Sq. D.	U.S.	440	60	150	1000
Wells	8	4	Turb.	Layne & Bowler	A/L-Sq. D.	U.S.	440	60	150	1000
	9	5	Turb.	Peerless	A/L-Sq. D.	G.E.	440	60	150	1000
	10	6	Turb.	Peerless	A/L-Sq. D.	G.E.	440	60	150	1000

* Item numbers correspond to item numbers in Appendixes B and C.

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Voltage	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Atrisco 2										
Wells	11	7	Turb.	Peerless	A/L-Sq. D.	G.E.	440	60	150	1000
	12	8	Turb.	Peerless	A/L-Sq. D.	G.E.	440	60	150	1000
	13	11	Turb.	Layne & Bowler	A/L-G.E.	U.S.	440	40	150	750
	14	12	Turb.	Layne & Bowler	A/L-G.E.	U.S.	440	40	150	750
Burton Boosters	16	1	Horiz.	Gardner-Denver	R/V-GE-M-Cont	Wsthse	2300	200	250	2500
		2	Horiz.	DeLaval	R/V-GE-M-Cont	E.M.	2300	200	250	2400
		4	Horiz.	Economy	R/V-GE-M-Cont	G.E.	2300	250	300	2800
		5	Horiz.	Peerless	R/V-G.E.	G.E.	4160	350	275	4000
		6	Horiz.	Economy	R/V-G.E.	Ideal	4160	350	275	4000
Burton Wells	17	1	Turb.	Peerless	R/V-G.E.	Moturbo	440	300	431	1000
	18	2	Turb.	Johnston	R/V-Sq. D.	GE Sub.	2300	350	464	2250
	19	3	Turb.	Johnston	R/V-Sq. D.	GE Sub.	2300	350	458	2250
Canada Boosters	22	1	Turb.	F-Morse	Flo-Matcher	G.E.	440	40	345	330
		2	Turb.	F-Morse	Flo-Matcher	G.E.	440	40	345	330
		3	Turb.	F-Morse	A/L-Cut.Ham.	G.E.	440	40	345	325
		4	Turb.	F-Morse	A/L-Cut.Ham.	G.E.	440	40	345	325
	Boosters 3 and 4 have auxiliary Waukesha gas powered engines of 53 H.P.									
Candelaria Boosters	23	1	Horiz.	Economy	R/V-G.E.	Wsthse	4160	300	250	3500
		2	Horiz.	Economy	R/V-G.E.	Wsthse	2300	300	240	3800

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Volt-age	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Candelaria	24	1	Turb.	Layne & Bowler	A/L-G.E.	U.S.	440	60	150	1000
Wells	25	2	Turb.	Layne & Bowler	A/L-Cut.Ham.	U.S.	440	60	150	1000
	26	3	Turb.	Layne & Bowler	A/L-G.E.	U.S.	440	60	150	1000
	27	4	Turb.	Layne & Bowler	A/L-G.E.	U.S.	440	60	150	1000
Chas. Wells	29	1	Horiz.	Economy	R/V-G.E.	G.E.	4160	200	240	2800
Boosters		2	Horiz.	Economy	R/V-G.E.	G.E.	4160	200	240	2800
		3	Horiz.	F-Morse	R/V-G.E.	F.M.	4160	250	240	3500
		4	Horiz.	F-Morse	R/V-G.E.	F.M.	4160	250	240	3500
		5	Horiz.	DeLaval	R/V-G.E.	U.S.	4160	300	200	4500
	Boosters 1 and 2 have auxiliary Buda gas powered engines of 160 to 212 H.P.									
Don	30	1	Horiz.	F-Morse	A/L	F.M.	220/440	15	100	400
Boosters		2	Horiz.	F-Morse	A/L	F.M.	220/440	20	100	400
Duranes	32	1	Horiz.	Economy	R/V-G.E.	G.E.	4160	250	95	2800
Boosters		2	Horiz.	Peerless	R/V-Cut.Ham.	Wsthse	4160	400	95	5000
		3	Horiz.	Economy	R/V-G.E.	G.E.	4160	250	100	2800
		4	Horiz.	Peerless	R/V-Cut.Ham.	Wsthse	4160	400	100	5000
	Boosters 1 and 3 have auxiliary Buda gas powered engines of 160 to 212 H.P.									
Duranes	33	1	Turb.	Peerless	R/V-A.C.	G.E.	440	100	--	2100
Wells	34	2	Turb.	Peerless	R/V-G.E.	L.A.	440	100	--	2100
	35	3	Turb.	Peerless	R/V-A.C.	U.S.	440	200	265	2750
	36	4	Turb.	Peerless	R/V-A.C.	U.S.	440	200	265	1200
	37	5	Turb.	Peerless	R/V-A.C.	U.S.	440	200	265	1300
	38	6	Turb.	Peerless	R/V-A.C.	U.S.	440	125	265	1500
	39	7	Turb.	Peerless	R/V-A.C.	U.S.	440	200	--	2000

Appendix A (Continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Volt-age	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Eubank	41	1	Horiz.	F-Morse	R/V-G.E.	Wsthse	2300	250	256	2900
Boosters		2	Horiz.	F-Morse	R/V-G.E.	F.M.	2300	250	256	3000
		3	Horiz.	Peerless	A/L-A.C.	L.A.	2300	250	256	2600
		4	Horiz.	Peerless	A/L-Sq. D.	--	2300	450	252	5400
		6	Horiz.	Peerless	A/L-Sq. D.	--	2300	450	252	5400
		8	Horiz.	Peerless	A/L-Sq. D.	--	2300	450	252	5400
Glenwood	43	1	Turb.	F-Morse	A/L-C.H.	G.E.	440	125	272	1350
Boosters		2	Turb.	F-Morse	A/L-C.H.	G.E.	440	125	272	1350
Griegos	45	1	Horiz.	Economy	R/V-Ideal	G.E.	4160	300	250	3400
Boosters		2	Horiz.	Economy	R/V-Ideal	G.E.	4160	400	250	5000
		3	Horiz.	Peerless	R/V-G.E.	L.A.	4160	400	250	5000
Griegos	46	1	Turb.	Peerless	R/V-G.E.	G.E.	440	100	130	2070
Wells	47	2	Turb.	Peerless	R/V-G.E.	G.E.	440	60	86	1600
	48	3	Turb.	Peerless	R/V-G.E.	G.E.	440	125	162	2070
	49	4	Turb.	Peerless	R/V-Sq. D.	G.E.	440	100	130	2070
	50	5	Turb.	Peerless	R/V-G.E.	G.E.	440	125	173	2000
Gutierrez	52	1	Turb.	F-Morse	A/L-Cut.Ham.	G.E.	2300	200	141	4680
Boosters		2	Turb.	F-Morse	A/L-Cut.Ham.	G.E	2300	200	141	4680
Kiva	54	1	Turb.	F-Morse	A/L-Cut.Ham.	G.E.	440	100	141	1760
Boosters		2	Turb.	F-Morse	A/L-Cut.Ham.	G.E.	440	100	141	1760

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Voltage	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Leyendecker Boosters	56	1	Turb.	Johnston	A/L-A.C.	U.S.	2300	200	200	3000
		2	Turb.	Johnston	A/L-A.C.	U.S.	2300	200	200	3000
		3	Turb.	Johnston	A/L-A.C.	U.S.	2300	250	200	4000
		4	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	210	4000
Leyendecker Wells	57	1	Turb.	Peerless	A/L-G.E.	U.S.	2300	350	390	2700
	58	2	Turb.	Peerless	R/V-G.E.	U.S.	2300	350	425	2450
	59	3	Turb.	Peerless	R/V-G.E.	U.S.	2300	350	425	2400
	60	4	Turb.	Peerless	R/V-G.E.	U.S.	2300	350	430	2400
Linda Vista Boosters	62	1	Turb.	F-Morse	R/V-A.C.	F.M.	2300	100	160	1600
		2	Turb.	F-Morse	R/V-A.C.	F.M.	2300	100	160	2000
Lomas Boosters	64	1	Turb.	Layne & Bowler	A/L-A.C.	Wsthse	2300	125	175	2000
		2	Turb.	Layne & Bowler	A/L-A.C.	Wsthse	2300	125	175	2000
		3	Turb.	Layne & Bowler	A/L-A.C.	Wsthse	2300	150	175	2600
		4	Turb.	Layne & Bowler	A/L-A.C.	Wsthse	2300	150	175	2000
		5	Turb.	Johnston	A/L-G.E.	Wsthse	2300	250	180	4000
Lomas Well	65	1	Turb.	Johnston	R/V-Sq. D.	G.E.	2300	400	853	1500
Love Wells	68	1	Turb.	Peerless	R/V-G.E.	Moturbo	440	250	590	1275
	69	2	Turb.	Johnston	R/V-G.E.	A.C.	440	250	620	1200
	70	3	Turb.	Johnston	R/V-G.E.	A.C.	440	350	620	1700
	71	4	Turb.	Johnston	R/V-G.E.	A.C.	440	350	620	1650
	72	5	Turb.	Johnston	R/V-G.E.	A.C.	440	350	620	1600

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Voltage	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Main Plant Boosters	76	1	Horiz.	DeLaval	M-Cont-G.E.	Century	2300	200	285	2200
		3	Horiz.	DeLaval	M-Cont-G.E.	E.M.	2300	250	285	2800
Main Plant Wells	77	2	Turb.	Peerless	A/L-Cut.Ham.	U.S.	440	50	--	1000
	78	11	Turb.	Peerless	A/L-G.E.	U.S.	440	50	--	750
	79	13	Turb.	Layne & Bowler	A/L-Cut.Ham.	U.S.	440	50	--	750
	80	14	Turb.	Peerless	A/L-Cut.Ham.	U.S.	440	50	--	1000
	81	17	Turb.	Peerless	A/L-Sq. D.	U.S.	440	60	--	1000
	82	18	Turb.	Pomona	A/L-G.E.	G.E.	440	60	--	1000
	83	19	Turb.	Peerless	A/L-A. Brad	U.S.	440	75	--	1000
Miles (Atrisco Leg) Boosters	84	2	Horiz.	Economy	R/V-Ideal	Ideal	4160	350	300	4000
		3	Horiz.	Economy	R/V-Ideal	Ideal	4160	350	300	4000
Miles (San Jose Leg) Booster	85	1	Horiz.	Economy	R/V-G.E.	Wsthse	2300	300	200	4000
Ponderosa Boosters	86	1	Turb.	Johnston	R/V-A.C.	U.S.	2300	250	164	4000
		2	Turb.	Johnston	R/V-A.C.	U.S.	2300	200	164	3250
		3	Turb.	Johnston	R/V-A.C.	U.S.	2300	200	164	3250
Ponderosa Well	87	1	Turb.	Johnston	A/L-Sq. D.	G.E.	440	100	862	350
San Jose Boosters	91	1	Turb.	Johnston	A/L-G.E	U.S.	2300	250	265	3200
		2	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	265	3200
		3	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	265	3200
		4	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	265	3200

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Volt-age	Motor H.P.	Total Dynamic Head (ft.)	Rated GPM
San Jose	92	1	Turb.	F-Morse	A/L-Sq. D.	G.E.	440	60	--	750
Wells	93	2	Turb.	F-Morse	A/L-Sq. D.	G.E.	440	60	--	750
	94	3	Turb.	Layne & Bowler	A/L-Sq. D.	U.S.	440	60	--	1000
	95	7	Turb.	Peerless	R/V-A.C.	L.A.	440	100	180	1500
	96	8	Turb.	Johnston	R/V	G.E.	440	150	180	2375
	97	10	Turb.	Johnston	A/L	G.E.	440	150	180	2375
Santa Barbara	99	1	Horiz.	Economy	R/V-G.E.	G.E.	4160	200	210	2800
Boosters		2	Horiz.	Economy	R/V-G.E.	G.E.	4160	200	210	2800
		3	Horiz.	Peerless	R/V-Cut.Ham.	E.P.	4160	300	210	4200
		4	Horiz.	Peerless	R/V-Cut.Ham.	E.P.	4160	300	210	4200
		5	Horiz.	DeLaval	R/V-G.E.	U.S.	4160	250	200	4200
	Pumps 1 and 2 have auxiliary Buda gas powered engines of 160 to 212 H.P.									
Supper Rock	101	1	Horiz.	F-Morse	A/L-A.C.	F.M.	220/440	10	95	250
Boosters		2	Horiz.	F-Morse	A/L-A.C.	F.M.	220/440	10	95	250
Thomas	103	1	Turb.	Peerless	R/V-Wsthse	G.E.	4160	600	330	6000
Boosters		2	Turb.	Peerless	R/V-Wsthse	G.E.	4160	350	330	3500
		3	Turb.	Peerless	R/V-Wsthse	G.E.	4160	350	330	3500
Thomas	104	1	Turb.	Peerless	A/L-G.E.	G.E.	440	350	530	1800
Wells	105	2	Turb.	Peerless	R/V-G.E.	G.E.	440	350	570	1800
	106	3	Turb.	Peerless	R/V-G.E.	G.E.	440	350	570	1800
	107	4	Turb.	Peerless	R/V-G.E.	G.E.	440	350	570	1800

Appendix A (continued)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Volt-age	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
Valley Gardens	109	1	End Suctn.	Peerless	A/L-AutoCon	Century	220/440	1.5	150	20
Boosters		2	End Suctn.	Peerless	A/L-AutoCon	Newman	220/440	7.5	150	150
		3	End Suctn.	Peerless	A/L-AutoCon	Newman	220/440	15.0	150	300
		4	End Suctn.	Peerless	A/L-AutoCon	Newman	220/440	25.0	150	500
Valley Gardens	110	A	Turb.	Layne & Bowler	A/L-AutoCon	--	440	40.0	350	600
Wells	111	B	Turb.	Layne & Bowler	A/L-AutoCon	--	440	17.5	200	150
Vol-Andia	113	1	Turb.	Peerless	A/L-G.E.	L.A.	2300	300	200	4500
Boosters		2	Turb.	Peerless	A/L-G.E.	L.A.	2300	250	200	4000
		3	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	185	4500
		4	Turb.	Johnston	A/L-G.E.	U.S.	2300	250	185	4000
Vol-Andia	114	1	Turb.	Johnston	A/L-Sq. D.	G.E.	2300	250	256	3000
Wells	115	2	Turb.	Johnston	R/V-Sq. D.	G.E.	2300	300	304	3000
	116	3	Turb.	Johnston	A/L-Sq. D.	G.E.	2300	300	297	3000
	117	4	Turb.	Johnston	A/L-Sq. D.	G.E.	2300	300	283	3000
	118	5	Turb.	Johnston	A/L-Sq. D.	G.E.	2300	300	289	3000
	119	6	Turb.	Johnston	A/L-Sq. D.	G.E.	2300	300	275	3000
West Mesa	121	1	Horiz.	Peerless	R/V-G.E.	Wsthse	440	100	250	1000
Boosters		2	Horiz.	Peerless	R/V-G.E.	Wsthse	440	40	235	400
		3	Horiz.	Peerless	R/V-G.E.	Wsthse	440	40	235	400
		4	Horiz.	DeLaval	R/V-G.E.	U.S.	440	200	250	2000

Appendix A (concluded)

Facility Name	Item No.	Pump No.	Pump Type	Pump Make	Starter Type and Make	Motor Make	Voltage	Motor H.P.	Total Dynamic Head (ft)	Rated GPM
West Mesa	122	1	Turb.	Peerless	R/V-G.E.	L.A.	440	50	300	500
Wells	123	2	Turb.	Johnston	R/V-Sq. D.	G.E.	2300	250	45	1750
Yale	125	1	Horiz.	DeLaval	R/V-G.E.	E.M.	2300	200	246	2500
Boosters		2	Horiz.	DeLaval	R/V-G.E.	Cent.	2300	250	246	2800
		3	Horiz.	DeLaval	R/V-G.E.	F.M.	2300	250	252	2800
		4	Horiz.	F-Morse	R/V-Ideal	F.M.	2300	300	250	4000

Appendix B

ALBUQUERQUE WATERWORKS RESERVOIRS AND SETTLING BASIN (Construction Details)

Appendix B

ALBUQUERQUE WATERWORKS
RESERVOIRS AND SETTLING BASIN
(Construction Details)

Item No.	Name	Date Built	Type Construction	Capacity (gal)	Effective Depth (ft)	Gallons/Foot of Depth
5	Atrisco 1	1950	Rect. Conc.	81,000	10.0	8,100
15	Atrisco 2	1962	Steel	3,000,000	32.0	93,750
20	Burton 1	1923	Rect. Conc.	3,033,000	20.7	146,522
21	Burton 2	1955	Circ. Conc.	6,000,000	20.7	289,855
28	Candelaria	1964	Steel	620,000	23.6	26,270
31	Don	1955	Steel	4,030,000	35.0	115,145
40	Duranes	1955	Prestressed	4,286,000	28.5	150,000
42	Franciscan	1960	Steel	1,529,000	35.0	43,690
44	Glenwood	1964	Prestressed	1,700,000	40.0	42,500
51	Griegos	1962	Steel	3,000,000	32.0	93,750
53	Gutierrez	1960	Steel	6,003,000	31.2	192,400
55	Kiva	1964	Prestressed	2,820,000	32.0	88,125
61	Leyendecker	1960	Steel	6,001,000	34.0	176,500
63	Linda Vista	1960	Steel	5,958,000	34.0	175,235
66	Lomas 1	1964	Pritzger	6,000,000	26.5	226,415
67	Lomas 2	1953	Prestressed	3,985,000	26.5	150,375
73	Love 1	1949	Rect. Conc.	3,367,000	19.9	169,195
74	Love 2	1950	Rect. Conc.	3,367,000	19.9	169,195
75	Love 3	1959	Prestressed	6,000,000	19.9	301,505
88	Ponderosa	1960	Steel	6,027,000	35.5	169,775
89	Ridgecrest	1942	Circ. Conc.	2,612,000	22.0	118,700

* Item numbers correspond to item numbers in Appendixes A and C.

Appendix B (concluded)

Item No.	Name	Date Built	Type Construction	Capacity (gal)	Effective Depth (ft)	Gallons/Foot of Depth
90	Sandia	1949	Steel	125,000	22.0	5,680
98	San Jose	1964	Steel	2,500,000	36.6	68,305
100	Simms	1964	Prestressed	2,520,000	41.7	60,430
102	Supper Rock	1960	Steel	4,014,000	29.0	138,410
108	Thomas	1959	Steel	6,051,000	31.8	190,300
112	Valley Gardens	1963	Steel	500,000	32.0	15,625
120	Vol Andia	1962	Steel	6,000,000	32.0	187,500
124	West Mesa	1955	Prestressed	4,005,000	18.3	218,850
126	Yale	1924	Rect. Conc.	8,062,000	18.3	440,545

Appendix C

ALBUQUERQUE WATERWORKS FACILITIES - DAMAGE PREDICTIONS

Appendix C

ALBUQUERQUE WATERWORKS FACILITIES - DAMAGE PREDICTIONS*

Item† No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage‡	Predicted Equipment Damage or Reservoir Status
	Atrisco Facilities				
1	Field 1, Booster Station	Reinforced Concrete Sheet Metal Roof (1-1/2 Story)	2.8	Roof torn off, windows and doors blown in, minor structural cracks in walls	Damage to light equipment
2	Field 1, Well and Pump 1	Sheet Metal (1 Story)	2.8	Roof and walls torn off, windows and doors blown in	Damage to light equipment
3	Field 1, Well and Pump 9	Sheet Metal (1 Story)	2.7	Roof and walls torn off, windows and doors blown in	Damage to light equipment
4	Field 1, Well and Pump 13	Sheet Metal (1 Story)	2.6	Roof and walls torn off, windows and doors blown in	Damage to light equipment
5	Field 1, Settling Basin	Reinforced Concrete Sheet Metal Roof (1-1/2 Story)	2.6	Roof torn off, doors and windows blown in, walls cracked	Debris would likely cause blockage in outlet piping of this small reservoir
6	Field 2, Booster Station	Sheet Metal (1 Story)	2.7	Roof torn off, walls blown out	Controls and light equipment damaged; heavy equipment repairable

* Assumes Weapon 173 of Five Cities Study.

† The same item numbers are used in Appendixes A and B

‡ Based on data from URS Corporation and References 1, 7, 8, 10, and 12.

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
7	Field 2, Well and Pump 2	Sheet Metal (1 Story)	2.8	Roof and walls torn off, doors and windows blown in	Controls, etc. damaged; motor repairable
8	Field 2, Well and Pump 4	Sheet Metal (1 Story)	2.9	Totally demolished	Controls, etc. damaged; motor repairable
9	Field 2, Well and Pump 5	Sheet Metal (1 Story)	2.7	Totally demolished	Controls, etc. damaged; motor repairable
10	Field 2, Well and Pump 6	Sheet Metal (1 Story)	2.9	Totally demolished	Controls, etc. damaged; motor repairable
11	Field 2, Well and Pump 7	Wood (1 Story)	2.9	Totally demolished	Light equipment damaged; heavy equipment recoverable
12	Field 2, Well and Pump 8	Sheet Metal (1 Story)	2.7	Totally demolished	Light equipment damaged; heavy equipment recoverable
13	Field 2, Well and Pump 11	Sheet Metal (1 Story)	2.9	Totally demolished	Light equipment damaged. heavy equipment recoverable
14	Field 2, Well and Pump 12	Sheet Metal (1 Story)	2.8	Totally demolished	Light equipment damaged; heavy equipment recoverable
15	Field 2, Reservoir	Welded Steel	2.7	Minor structural damage to walls by flying missiles	Little if any leakage, operable postattack
	Burton Facilities				
16	Booster Station	Masonry (1 Story)	7.5	Virtually demolished, little left standing	Heavy booster units repairable; light equipment and controls damaged or destroyed

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
17	Well and Pump 1	Masonry (1 Story)	7.5	Virtually demolished, little left standing	Controls destroyed; motor probably repairable
18	Well and Pump 2	Masonry (1 Story)	7.4	Virtually demolished, little left standing	Controls destroyed; motor probably repairable
19	Well and Pump 3	Masonry (1 Story)	7.5	Virtually demolished, little left standing	Controls destroyed; motor probably repairable
20, 21	Reservoirs 1 and 2	Circular Reinforced Concrete	7.5	Roof totally collapsed; minor missile damage to exposed upper walls, outlets ruptured	Total loss of water at outlets
	Canada Facilities				
22	Canada Pump Station	Masonry (1 Story)	5.9	Roof torn off, windows and doors blown in, walls severely cracked, some wall failure	Missile damage to controls and light equipment; booster units repairable
	Candelaria Facilities				
23	Booster Station	Reinforced Concrete Sheet Metal Roof (1-1/2 Story)	3.6	Roof torn off, doors and windows blown in; walls cracked, but standing	Missile damage to light equipment
24	Well and Pump 1	Sheet Metal (1 Story)	3.6	Roof torn off, walls and frame totally collapsed	Light equipment extensively damaged
25	Well and Pump 2	Sheet Metal (1 Story)	3.5	Roof torn off, walls and frame totally collapsed	Light equipment extensively damaged

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
26	Well and Pump 3	Sheet Metal (1 Story)	3.6	Roof torn off, walls and frame totally collapsed	Light equipment extensively damaged
27	Well and Pump 4	Sheet Metal (1 Story)	3.4	Roof torn off, walls and frame totally collapsed	Light equipment extensively damaged
28	Ground Storage	Welded Steel	3.6	Roof collapsed; minor damage to walls from flying missiles	Possible slight leakage; essentially still operable
	Charles Wells Facilities				
29	Booster Station	Masonry (2 Story)	6.6	Roof torn off, extensive wall damage and collapse; 75% demolished	All light equipment and controls extensively damaged; pumps, engines, and motors repairable
	Don Facilities				
30	Booster Station	Aluminum (1 Story)	1.8	Walls and roof dished, structure distorted, doors and windows blown in	Light damage due to missiles; light damage to piping supported on walls and to controls near walls
31	Reservoir	Welded Steel	1.7	Roof deflected slightly, walls undamaged	Operable postattack
	Duranes Facilities				
32	Booster Station	Sheet Metal (1-1/2 Story)	2.7	Roof and siding torn off, frame distorted	Damage to light equipment, heavy equipment repairable
33	Well and Pump 1	Masonry (1 Story)	2.7	Roof torn off, door and windows blown in, minor structural damage	Metal missiles do light damage to equipment

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
34	Well and Pump 2	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
35	Well and Pump 3	Sheet Metal (1 Story)	2.7	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
36	Well and Pump 4	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
37	Well and Pump 5	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
38	Well and Pump 6	Sheet Metal (1 Story)	2.7	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
39	Well and Pump 7	Sheet Metal (1 Story)	2.5	Roof and siding torn off, frame distorted	Metal missiles do light damage to equipment
40	Ground Storage	Prestressed Concrete	2.7	Roof distorted or blown in; missile damage to concrete walls	Slight leakage; still operable without immediate repair
	Eubank Facilities				
41	Eubank Booster Station	Masonry	13.3	Totally demolished	Some heavy equipment may be salvageable for use during reconstruction
	Franciscan Facilities				
42	Franciscan Reservoir	Welded Steel	1.7	Roof slightly deflected, walls undamaged	No leakage, fully operable

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Glenwood Facilities				
43	Booster Station	Masonry (1-1/2 Story)	6.2	Roof torn off; walls 50% to 75% demolished	Light equipment destroyed; heavy equipment generally repairable
44	Reservoir	Prestressed Concrete	6.2	Roof collapsed, minor wall structural damage	Total loss of water at outlet
	Griegos Facilities				
45	Booster Station	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Damage to light equipment
46	Well and Pump 1	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Damage to light equipment
47	Well and Pump 2	Sheet Metal (1 Story)	2.6	Roof and siding torn off, frame distorted	Damage to light equipment
48	Well and Pump 3	Sheet Metal (1 Story)	2.5	Roof and siding torn off, frame distorted	Damage to light equipment
49	Well and Pump 4	Sheet Metal (1 Story)	2.7	Roof and siding torn off, frame distorted	Damage to light equipment
50	Well and Pump 5	Masonry (1 Story)	2.7	Roof torn off, doors and windows blown in, minor structural damage	Damage to light equipment

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
51	Ground Storage	Welded Steel	2.6	Roof distorted, partially collapsed; minor damage to walls from missiles	Little if any leakage
	Gutierrez Facilities				
52	Booster Station	Masonry (1-1/2 Story)	6.4	Roof torn off; walls 50% to 75% demolished	Extensive damage to equipment
53	Reservoir	Welded Steel	6.4	Roof collapsed, minor wall structural damage; outlet ruptured	Total loss of water at outlet
	Kiva Facilities				
54	Booster Station	Masonry (1-1/2 Story)	6.3	Roof torn off; walls 50% to 75% demolished	Extensive damage to equipment
55	Reservoir	Prestressed Concrete	6.3	Roof collapsed, minor structural damage to walls; outlet ruptured	Total loss of water at outlet
	Leyendecker Facilities				
56	Booster Station	Masonry (2 Story)	5.1	Roof blown off, windows and doors blown in, walls cracked and distorted, some wall failure	Extensive damage to light equipment; heavy equipment generally repairable
57	Well and Pump 1	Masonry (1 Story)	5.1	Roof blown off, windows and doors blown in, walls cracked and distorted, some wall failure	Extensive damage to light equipment; heavy equipment generally repairable

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
58	Well and Pump 2	Masonry (1 Story)	5.8	Roof blown off, windows and doors blown in, walls cracked and distorted, some wall failure	Extensive damage to light equipment; heavy equipment generally repairable
59	Well and Pump 3	Masonry (1 Story)	4.6	Roof blown off, windows and doors blown in, walls cracked and distorted, some wall failure	Extensive damage to light equipment; heavy equipment generally repairable
60	Well and Pump 4	Masonry (1 Story)	4.8	Roof blown off, windows and doors blown in, walls cracked and distorted, some wall failure	Extensive damage to light equipment; heavy equipment generally repairable
61	Reservoir	Welded Steel	5.1	Roof partially collapsed, insignificant wall damage	Little if any leakage, operable postattack
	Linda Vista Facilities				
62	Booster Station	Masonry (1-1/2 Story)	12.5	Totally demolished	Heavy equipment salvageable for use during reconstruction
63	Reservoir	Welded Steel	12.5	Totally demolished	--

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Lomas Facilities				
64	Booster Station	Masonry (2 Story)	13.0	Totally demolished	Some heavy equipment may be salvageable
65	Well and Pump 1	Masonry (1 Story)	13.0	Totally demolished	Some heavy equipment may be Salvageable
66 67	Reservoirs 1 and 2	Prestressed Concrete	13.0	Totally demolished	--
	Love Facilities				
68	Well and Pump 1	Masonry (1 Story)	13.3	Totally demolished	Pump and column may be salvageable
69	Well and Pump 2	Masonry (1 Story)	12.8	Totally demolished	Motor and pump may be salvageable
70	Well and Pump 3	Masonry (1 Story)	13.7	Totally demolished	Pump and column may be salvageable
71	Well and Pump 4	Masonry (1 Story)	14.2	Totally demolished	--
72	Well and Pump 5	Masonry (1 Story)	13.2	Totally demolished	Pump and column may be salvageable for use during reconstruction
73 74 75	Reservoirs 1, 2, and 3	Reinforced Concrete	13.3	Roof collapsed, extensive wall structural damage; outlets ruptured	No storage. Totally unusable

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Main Plant Facilities				
76	Booster	Reinforced Concrete (2-story, frame roof)	4.0	Roof, windows and doors blown off; some structural failure of walls due to old, substandard construction	Extensive missile damage to light equipment; possible salvage of heavy equipment
77	Well 2	Information Unavailable	3.9	--	Missile damage to light equipment
78	Well 11	Information Unavailable	3.6	--	Missile damage to light equipment
79	Well 13	Information Unavailable	4.0	--	Missile damage to light equipment
80	Well 14	Information Unavailable	3.7	--	Missile damage to light equipment
81	Well 17	Information Unavailable	3.8	--	Missile damage to light equipment
82	Well 18	Information Unavailable	3.6	--	Missile damage to light equipment
83	Well 19	Information Unavailable	3.6	--	Missile damage to light equipment
	Miles Facilities				
84, 85	Miles Booster Station	Masonry (1 Story)	5.4	Roof torn off, windows and doors blown in, walls cracked and distorted with some failure	Light equipment destroyed

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Ponderosa Facilities				
86	Booster Station	Masonry (2 Story)	6.8	Roof torn off; walls 50% to 75% demolished	Extensive missile damage to equipment
87	Well and Pump 1	Masonry (1 Story)	6.8	Roof torn off; walls 50% to 75% demolished	Extensive damage to equipment
88	Reservoir	Welded Steel	6.8	Roof collapsed, minor wall structural damage	Total loss of water at outlet
	Ridgecrest Facilities				
89	Reservoir	Prestressed Concrete	13.0	Totally demolished	--
	Sandia Facilities				
90	Reservoir	Bolted Steel	12.8	Totally demolished	--
	San Jose Facilities				
91	Booster Station	Reinforced Concrete (2 Story)	4.4	Roof torn off, windows and doors blown in, minor structural damage	Light equipment and controls damaged or destroyed beyond repair
92	Well and Pump 1	Sheet Metal (1 Story)	4.3	Totally demolished	Motor repairable: light equipment extensively damaged
93	Well and Pump 2	Sheet Metal (1 Story)	4.1	Totally demolished	Motor repairable; light equipment extensively damaged

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
94	Well and Pump 3	Sheet Metal (1 Story)	4.5	Totally demolished	Motor repairable; light equipment extensively damaged
95	Well and Pump 7	Masonry (1 Story)	4.5	Roof torn off, windows and doors blown in, walls cracked but in place	Light equipment damaged
96	Well and Pump 8	Masonry (1 Story)	4.1	Roof torn off, windows and doors blown in, walls cracked but in place	Light equipment damaged
97	Well and Pump 10	Masonry (1 Story)	4.4	Roof torn off, windows and doors blown in, walls cracked but in place	Light equipment damaged
98	Reservoir	Welded Steel	4.4	Roof collapsed; minor structural damage to walls from flying missiles	Useable postattack
	Santa Barbara Facilities				
99	Booster Station	Sheet Metal (1-1/2 Story)	4.2	Totally demolished	Extensive missile damage to controls and light equipment; booster units essentially undamaged
	Simms Facilities				
100	Simms Reservoir	Prestressed Concrete	5.5	Roof collapsed, walls relatively unaffected	Debris may clog outlet but can be cleaned out

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Supper Rock Facilities				
101	Pumping Station	Sheet Metal (1 Story)	13.0	Totally demolished	Possibly some heavy equipment salvageable with major effort
102	Reservoir	Welded Steel	13.0	Totally demolished	--
	Thomas Facilities				
103	Booster Station	Masonry (2 Story)	5.8	Roof torn off, windows and doors blown in, walls cracked and distorted with some failure	Booster units repairable; controls and light equipment heavily damaged
104	Well and Pump 1	Masonry (1 Story)	5.8	Roof torn off, windows and doors blown in, walls cracked and distorted with some failure	Motor and exposed major piping essentially undamaged; light equipment damaged or destroyed
105	Well and Pump 2	Masonry (1 Story)	6.1	Roof torn off, windows and doors blown in, walls cracked and distorted with some failure	Motor exposed major piping essentially undamaged; light equipment damaged or destroyed

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
106	Well and Pump 3	Masonry (1 Story)	5.1	Roof torn off, windows and doors blown in, minor wall structural cracks and distortion	Light equipment damaged; booster units repairable
107	Well and Pump 4	Masonry (1 Story)	5.4	Roof torn off, windows and doors blown in. walls cracked and distorted with some failure	Light equipment damaged; booster units repairable
108	Reservoir	Welded Steel	5.8	Roof collapsed, minor wall structural damage; outlet ruptured	Total loss of water at outlet works
	Valley Gardens Facilities				
109	Booster Station	Masonry (1 Story)	2.3	Roof turn off, windows and doors blown in, walls cracked and spalled	Controls and light equipment damaged. Booster units essentially undamaged
110	Well and Pump A	Masonry (1 Story)	2.3	Roof torn off, windows and doors blown in, walls cracked and spalled	Light missile damage to controls and light equipment
111	Well and Pump B	Masonry (1-Story)	2.3	Roof torn off, windows and doors blown in, walls cracked and spalled	Light missile damage to controls and light equipment
112	Reservoir	Welded Steel	2.3	Roof distorted, partially collapsed, walls not affected	Useable postattack

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
	Vol Andia Facilities				
113	Booster Station	Masonry (1 Story)	4.3	Roof collapsed; windows, louvres and doors blown in; walls cracked but in place	Moderate damage to light equipment and controls
114	Well and Pump 1	Masonry (1 Story)	4.3	Roof blown off, windows and doors blown in, minor structural damage to walls	Light equipment damaged by debris
115	Well and Pump 2	Masonry (1 Story)	5.1	Roof collapsed, windows and doors blown in, minor structural damage to walls	Moderate equipment damage
116	Well and Pump 3	Masonry (1 Story)	4.3	Roof torn off, windows and doors blown in, minor structural damage to walls	Light equipment damaged by roof and debris
117	Well and Pump 4	Masonry (1 Story)	4.4	Roof torn off, windows and doors blown in, minor structural damage to walls	Light equipment damaged by roof and debris
118	Well and Pump 5	Masonry (1 Story)	4.0	Roof torn off, windows and doors blown in, minor structural damage to walls	Light equipment damaged by roof and debris
119	Well and Pump 6	Masonry (1 Story)	4.1	Roof torn off, windows and doors blown in, minor structural damage to walls	Light equipment damaged by roof and debris

Appendix C (continued)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
120	Reservoir	Welded Steel	4.3	Roof collapsed; walls subject to minor damage from missiles	Possibly some leakage; useable postattack
	West Mesa Facilities				
121	Booster Station	Masonry (1 Story)	1.9	Roof bowed, doors and windows blown out, structure walls undamaged	Light equipment damaged by missiles; all equipment repairable
122	Well and Pump 1	Masonry (1 Story)	1.9	Roof bowed, doors and windows blown out, structure undamaged	Minor damage to light equipment
123	Well and Pump 2	Masonry (1 Story)	1.9	Roof bowed, doors and windows blown out, structure undamaged	Minor damage to light equipment
124	Reservoir	Reinforced Concrete	1.9	Roof deflected, walls undamaged	Fully useable postattack
	Yale Facilities				
125	Booster Station	Masonry (1 Story)	5.3	Roof torn off, windows and doors blown in, walls cracked and distorted with some failure	Controls damaged or destroyed; all but heaviest equipment extensively damaged

Appendix C (concluded)

Item No.	Name	Construction Type	Estimated Over-Pressure (psi)	Predicted Structural Damage	Predicted Equipment Damage or Reservoir Status
126	Reservoir	Reinforced Concrete	5.3	Roof 75% collapsed into reservoir; walls unaffected	Debris from roof likely to clog outlet
	Miscellaneous				
127	Old Town Bridge (Pipe lines)	10 in. Diameter on Piers	2.8	Possible damage from missiles; overpressure damage dependent upon support and spacing	(Does not apply)
128	Barelas Bridge (Pipe lines)	22 in. Diameter	3.6	Possible damage from missiles; overpressure damage dependent on support and spacing	(Does not apply)
129	Central Control Building	Masonry (1 Story with basement)	6.2	Building demolished; walls and roof mostly off-site; floor slab cracked and deflected downward	Totally destroyed
130	City Yards	Miscellaneous sheet metal and masonry buildings	4.0	Sheet Metal buildings stripped of siding and roof; frames distorted slightly; roof of masonry buildings collapsed and walls cracked	Damage to all vehicles and equipment

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VULNERABILITY OF THE ALBUQUERQUE WATER SUPPLY SYSTEM

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Robert L. Nevin

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13. ABSTRACT

This report assesses the vulnerability of the Albuquerque water supply system to damage from a hypothetical nuclear weapon attack. Probable damage to facilities and casualties to personnel are considered, as well as the possible loss of support from interrelated systems.

Based on the damage and casualty predictions, the postattack capabilities are evaluated, and these capabilities are discussed in relation to post attack requirements. Although the study did not include recovery analysis, some lapse of time and the accomplishment of remedial measures had to be considered to allow a meaningful discussion of capability.

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